RECOMMENDATIONS OF THE STATE WATER CONTRACTORS REGARDING THE SACRAMENTO-SAN JOAQUIN STRIPED BASS RESOURCE

PHASE 1 • AUGUST 1987

STATE WATER CONTRACTORS

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BAY DELTA HEARINGS

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STATE WATER CONTRACTORS

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SUMMARY AND CONCLUSIONS

Striped bass were introduced to the Bay-Delta late in the last century. They thrived and today support an important recreational fishery in the Bay-Delta system. During the past several decades, there has been a decline in the numbers of adult striped bass. Great efforts have been made to understand why the decline occurred and how to correct it, but to date, the reasons for the decline are poorly understood.

There is general agreement that, while the mechanisms are poorly understood, operation of the state and federal water projects (SWP/CVP) has contributed to the striped bass problem. In recognition of this, the Department of Water Resources (DWR) agreed to mitigate for striped bass losses that occur at its Delta Pumping Plant. The agreement executed by DWR and the California Department of Fish and Game (CDFandG) in December 1986, is presented as Appendix A of this report. This agreement addresses striped bass, steelhead, and salmon losses and provides the following:

- $15 million to initiate the program;
- About $2 million/year for measures directed first at protection of native stocks and secondarily at hatchery production.

Mitigation for native striped bass losses will be achieved under this agreement through hatchery production and facilities to "grow out" young striped bass salvaged at the SWP Skinner Fish Protection Facility located just upstream of the state pumping plant. These fish will be released back into the Bay-Delta system after they reach a size where they would have a relatively high probability of survival. In addition, some of the money will be spent to learn more about striped bass.

A similar agreement for striped bass hatchery production was reached by CDFandG and Pacific Gas and Electric Company (PGandE) in 1983. Negotiations have begun for an agreement with the Bureau of Reclamation covering striped bass losses at the federal pumping plant (CVP). These agreements will provide substantial near-term support for the striped bass stock. However, these agreements, by themselves, will not result in long-term restoration of the native striped bass population.

There appear to be numerous factors other than operation of the SWP/CVP affecting striped bass. The factors include declines in reproductive potential and food supplies, exposure to toxics, and entrainment losses. There is a marked lack of consensus among experts as to the relative importance of these factors. There is, however, general consensus that modification of patterns of flow in the Delta and out of the Delta into Suisun Bay (Delta outflow) are important. Delta outflow controls the location of the entrapment zone, and outflow standards were included in D-1485 for this reason. The patterns of flow in the Delta (including Delta cross-channel flow and periodic reverse flow in the lower San Joaquin River) were also addressed in D-1485. However, without construction of facilities, correcting the cross-channel and reverse flow problems would require severe curtailment of SWP/CVP exports and would result in larger shortages for the state and federal projects water users. The State Water Contractors, the Department of Water Resources, and numerous others have made great efforts to gain approval to build facilities to correct this problem without success. Of all of the options for facilities, fishery experts are in general agreement that the Peripheral Canal is the best technical solution to the problem of flow patterns in the Delta. However, it would be premature, at this time, to recommend a specific solution. Instead, as recommended below, a series of comprehensive studies should be undertaken to verify this consensus or to determine if some other type of Delta facility would be more desirable.

SUMMARY

The striped bass situation seems to be as follows:

- The decline of striped bass that began several decades ago has been even sharper in the last decade.
- We now know that we can grow striped bass in hatcheries. (Hatchery production is about 1 million fish per year). We did not know this when D-1485 was adopted. The ability to grow large numbers of striped bass in hatcheries is a major change in the striped bass situation.
- Despite numerous studies of the striped bass problem since D-1485, there is little consensus among experts about the relative importance of various factors that appear to contribute to the problem.
- We now have agreements providing for the mitigation of losses of striped bass at the SWP pumping plant and the PGandE power plants at Antioch and Pittsburg.
- We strongly suspect that modification of flow patterns in the Delta is adversely affecting survival of larval and juvenile striped bass.
- We know that changing flow patterns without construction of Delta facilities would severely reduce the water available to both projects water users (and, possibly, other water rights holders).
- We know that the Peripheral Canal or other Delta facilities would markedly improve the flow patterns in the Delta.

CONCLUSIONS AND RECOMMENDATIONS

We conclude the following:

1. THE EXISTING MITIGATION AGREEMENTS PLUS THE YET-TO-BE-NEGOTIATED AGREEMENT ON THE CVP PUMPING PLANT PROVIDE REASONABLE PROTECTION FOR THE STRIPED BASS FISHERY AS AFFECTED BY THE DIRECT LOSSES AT THE CVP AND SWP DELTA PUMPING PLANTS AND PGANDE POWER PLANTS;

2. IN THE NEAR-TERM, ADDITIONAL SIGNIFICANT IMPROVEMENT CAN ONLY BE REASONABLY PROVIDED WITH SOME DEGREE OF CERTAINTY BY PRODUCING BASS IN HATCHERIES;

3. CORRECTION OF PROBLEMS ASSOCIATED WITH FLOW PATTERNS IN THE DELTA WITHOUT SEVERE IMPACTS ON THE PROJECTS WATER USERS CAN ***ONLY*** BE PROVIDED BY CONSTRUCTION OF DELTA FACILITIES; AND

4. EFFORTS TO FIND OUT WHAT IS WRONG WITH STRIPED BASS HAVE GENERALLY BEEN INCONCLUSIVE AND PROVIDE LITTLE BASIS FOR THE SETTING OF NEW STANDARDS FOR STRIPED BASS.

Based on these conclusions, we recommend the following:

1. UNTIL THERE IS ADEQUATE TECHNICAL BASIS FOR NEW STRIPED BASS STANDARDS, THE D-1485 STANDARDS SHOULD REMAIN IN EFFECT;

2. NEAR-TERM STEPS SHOULD BE TAKEN TO INCREASE THE NUMBERS OF STRIPED BASS. HATCHERY PRODUCTION SHOULD BE THE PRIMARY MEANS OF PROVIDING THIS INCREASE;

3. COMPREHENSIVE STUDIES SHOULD BE INITIATED TO PROVIDE ADEQUATE TECHNICAL BASIS FOR REVISING D-1485 STANDARDS AND TO ESTABLISH A FIRM BASIS FOR RECOMMENDING THE APPROPRIATE DELTA TRANSFER FACILITY. THE STUDIES SHOULD ADDRESS THE TOPICS LISTED BELOW. THE SWRCB SHOULD ASSEMBLE A MULTIDISCIPLINARY TASK FORCE TO MANAGE THE COMPREHENSIVE STUDIES;

4. BASED ON RESULTS OF THESE STUDIES, THE SWRCB SHOULD CONSIDER REVISION OF THE D-1485 STRIPED BASS OBJECTIVES AT EACH TRIENNIAL REVIEW OF THE BASIN PLAN; AND

5. DELTA TRANSFER FACILITIES SHOULD BE BUILT TO PROVIDE A LONG-TERM SOLUTION TO DELTA FLOW PATTERNS THAT ADVERSELY AFFECT THE STRIPED BASS POPULATION.

Near-term actions to support the striped bass population and areas of investigation to provide an adequate technical basis for revising D-1485 standards include:

- implementation of interim restrictions on the recreational harvest of striped bass which would include a slot size limit (lower and upper size limits) on striped bass to protect older, larger striped bass that provide a significant portion of the reproduction in the population, limits on the total number of bass an angler can harvest each year, initiation of a punch card reporting program, and promotion of the use of barbless hooks and catch and release sport fishing;

- increased enforcement efforts to reduce the incidence of illegal striped bass poaching;

- evaluation of existing hatchery-management practices and development of specific recommendations for improving hatchery production in terms of size of fish at release, genetics, release location, hatchery production objectives, and expansion of the existing hatchery planting program to help provide additional support in recovery of the adult population;

- construction of striped bass grow-out facilities for fish salvaged at the SWP;

- increased effort devoted to providing accurate monitoring information on the abundance, age structure, growth, condition, and survival of the juvenile and adult striped bass population, angler harvest, and the contribution of hatchery reared striped bass to the adult population to provide a basis for evaluating the effectiveness of interim actions and for recommending additional actions to be taken to ensure protection of adult striped bass;

- expansion of the data management efforts for all aspects of the program to provide efficient and rapid access to documented data bases which can be used to test various hypotheses and evaluate the potential effectiveness of various near- and long- term actions taken to meet the program goals;

- linkages between phytoplankton, zooplankton, and striped bass need to be defined and specific testable hypotheses established to provide a basis for examining relationships between factors such as Delta water quality or channel velocity and phytoplankton/zooplankton production;

- existing fishery surveys should be examined and critiqued to identify missing information that should be collected which would be useful in evaluating hypotheses and determining the effectiveness of each specific action taken to meet the program goals;

- monitoring of the health and condition of adult striped bass including the incidence of parasite infestation and body burden of toxic chemicals in specific tissues of the fish (e.g., gonads, liver, etc.) to provide a basis for assessing the overall health of striped bass, determining if potential health hazards exist associated with the consumption of adult striped bass, identifying and prioritizing the chemical toxicants that should be regulated more stringently, and providing a basis for evaluating improvements in the condition of the fish resulting from reductions in pollutant loadings;

- initiation of a detailed investigation of the viability of striped bass eggs and survival of larval and juvenile striped bass exposed to water quality conditions located in the major spawning and nursery areas;

- initiation of a detailed investigation of the potential effects of water quality conditions in various regions of the Bay-Delta on survival, growth, and production potential of phytoplankton and zooplankton that may be adversely effected by exposure to toxic chemicals (particularly agricultural pesticides and herbicides);

- implementation of a program to upgrade fish screening and protection systems at major agricultural, industrial, and municipal water diversions where striped bass are lost as a direct result of entrainment/impingement or indirectly as a result of increased predation. Sites to be included in this evaluation should include, but not be limited to, major industrial and municipal diversions, the SWP and the CVP intakes;

- initiation of a program to evaluate entrainment losses at the CVP intake and to determine the effectiveness of the existing fish diversion and salvage system. This evaluation program will provide the necessary basis for developing specific recommendations for modifications to the system to reduce entrainment losses and quantify unavoidable striped bass losses;

- initiation of an operational feasibility assessment to evaluate SWP/CVP project yield impacts, hydrologic conditions in the lower Sacramento River and Delta including the incidence of reversed flows in the San Joaquin River, and changes in water quality conditions attributable to closing the cross-channel for various durations. The feasibility assessment should be based on the timing of the occurrence of striped bass eggs and larvae in the Sacramento River (including a real-time striped bass monitoring program) and include consideration of various water- year scenarios and alternative project operational strategies. The assessment should evaluate the interaction between closing the cross-channel for a given period and the potential changes in hydrologic conditions in other areas of the system (e.g., increased reverse flow, etc.) that may offset the biological advantages of the altered cross-channel operations;

- quantification of the effect of reducing cross-channel diversion on striped bass survival and production;

- evaluation of the significance of between-day variance in the Bay-Delta hydrologic regime should be included in biological and operational assessments of historic and planned hydrologic conditions. Rapid changes in the hydrologic regime of the Bay- Delta may play an important role in influencing the geographic distribution and survival of young striped bass that are obscured in analyses based on average monthly conditions;

- initiation of an integrated hydrologic testing program for conducting the necessary biological and operational evaluations to assess the effectiveness of various hydrologic scenarios in providing conditions favorable for striped bass. Existing data available from the striped bass survey programs should be evaluated to establish a set of potential flow scenarios, each with a specific expectation of striped bass survival or production, that can be evaluated under field testing conditions. In this way, striped bass year-class strength can be evaluated while maintaining sufficient operating flexibility to perform and assess the potential effectiveness of several recommended hydrologic scenarios in a coordinated fashion within the constraints imposed by available water supplies and demands;

- evaluation of the available water supply in various water-year-types with the intent of minimizing the occurrence of reversed flow conditions in the San Joaquin River when reasonable. A complementary biological evaluation program should be established to collect necessary information to quantify the changes in the survival of striped bass attributable to the reduction in reversed flows.

Implementation of this program will require a high degree of cooperation among the participating parties. Evaluating the effectiveness of each hydrologic test condition will require extensive coordination and planning in terms of both the biological activities and the water supply/export levels which may limit or preclude testing in some years. Specific criteria need to be established in advance on the desired hydrologic condition and on the biological criteria which would serve to validate and quantify the biological benefits to striped bass. The State Board should establish a steering/advisory committee including representatives from various resources agencies, water project operators, the private sector, and recreational fishing interests to provide direction for this program, establish priorities for evaluations to be conducted, and monitor the findings of the program with the specific intent of developing recommendations for water quality and flow objectives to meet the goals of the striped bass program. The steering/advisory committee should be responsible for preparing an annual summary report to be presented to the State Board on the status of the near- and long-term program to protect the striped bass population and to set goals and priorities for the program. The steering/advisory committee would have responsibility for recommending actions to be taken in establishing or revising water quality objections for striped bass during the triennial review of the existing water quality control plan.

INTRODUCTION

The striped bass population of the Sacramento-San Joaquin system supports an active fishery in the Bay Area. Striped bass are also an important component of the aquatic community. There is considerable evidence to suggest that the striped bass population has declined during the past several decades. There has been considerable speculation and debate on the potential causes of this decline and on the actions which should be taken to protect the fishery resources. Striped bass respond to a complex array of factors which influence reproductive success, survival of young fish, and recruitment to the adult population. These factors include declines in reproductive potential and food supply, toxic chemicals, entrainment losses, and Delta hydrologic conditions. The relative significance of any one of these potential factors varies between life stages, and between years as a result of interactions between biotic and environmental variables. The population dynamics and response of striped bass to environmental conditions in the Bay-Delta are complex and poorly understood.

A comprehensive program is needed as a basis for defining and implementing the actions and standards necessary to accomplish the management of the striped bass stock. The goals of this program should be to (1) provide near-term protections for the striped bass stock to reverse the declining trend in abundance, (2) provide conditions which are conducive to an increase, over the long-term, in the numbers of striped bass inhabiting the Bay-Delta system, and (3) meet the above goals through a combination of measures that recognize and minimize impacts on other beneficial uses of Bay-Delta waters. There are many actions that can be taken to accomplish these goals. Some of these actions should be implemented on a near-term basis, while others involve development of a long-term program. For each action it is important that a plan be developed to evaluate and verify the actual benefit to the striped bass population.

In the following sections we briefly discuss the status of the striped bass stock and some of the many factors that potentially affect them. We conclude with a series of recommendations for achieving the goals described above and suggest near-term actions that should be considered to provide reasonable protection of the striped bass resource.

BACKGROUND

Striped bass are a large introduced fish abundant in the Bay-Delta which support an intensive sport fishery. Native to the Atlantic and Gulf of Mexico coastal waters, estuaries, and rivers, striped bass quickly became established in the Bay-Delta after their introduction in 1879 and 1882. The Bay-Delta population remains the only major one on the Pacific Coast. Reductions in the striped bass population have prompted considerable interest in the environmental requirements of the species.

Adult striped bass use the Bay and coastal waters for feeding during the summer months. In fall they move upstream, concentrating in San Pablo and Suisun Bays. In spring, mature bass move upstream to spawn in the Sacramento River between Colusa and Sacramento and in the San Joaquin River between Antioch and Venice. Spawning generally occurs from April through early June.

Males mature between age one and three and females usually between age four and six. Both sexes commonly live and reproduce until they are 12-15 years old (females up to 30 years old). Spawning is triggered by water temperatures. San Joaquin River spawning generally precedes Sacramento River spawning because of warmer water temperatures in the San Joaquin River.

Striped bass females are prolific, successfully spawning over a number of years. Large females have been reported to contain up to 4.5 million eggs. Striped bass fecundity (the number of eggs produced) increases as the bass grow older (Figure 1). Eggs are planktonic and non-adhesive. Suspension and initial exposure to freshwater are both essential for high egg survival. Once water hardening occurs, the eggs can tolerate salinities up to 10 ppt. After fertilization, exposure to low salinity water improves survival of striped bass eggs and larvae. Eggs hatch within 36-48 hours after fertilization at water temperatures of 17-18 C (62-65 F). Eggs tend to be concentrated near the bottom in midchannel.

Larvae (<6mm) are carried out of the upper Sacramento River into the Delta. Most enter the lower Sacramento River, but some pass into the lower San Joaquin River and central Delta via the Delta cross-channel and Georgiana Slough. Larvae become distributed throughout the western Delta and Suisun Bay above the entrapment zone, the location of which is determined by outflow. Larger larvae and juveniles are distributed farther downstream into the entrapment zone. Small larvae are distributed fairly evenly across the main channels of the western Delta. Larger larvae and juveniles tend to concentrate near the shoreline.

Young striped bass remain in and above the entrapment zone during their first summer, but migrate into San Pablo Bay and the central Bay in fall. Some young striped bass remain in the Delta during the winter, and these tend to concentrate in the lower San Joaquin River.

A striped bass hatchery propagation program has recently begun producing relatively large numbers of young-of-the-year and yearling striped bass for release into the Bay-Delta. The hatcheries, operated by private aquaculturists and the Department of Fish and Game, currently produce approximately 1 million young striped bass per year. The bass are tagged prior to release and subsequent tag recoveries in the recreational fishery will be used to evaluate the survival of

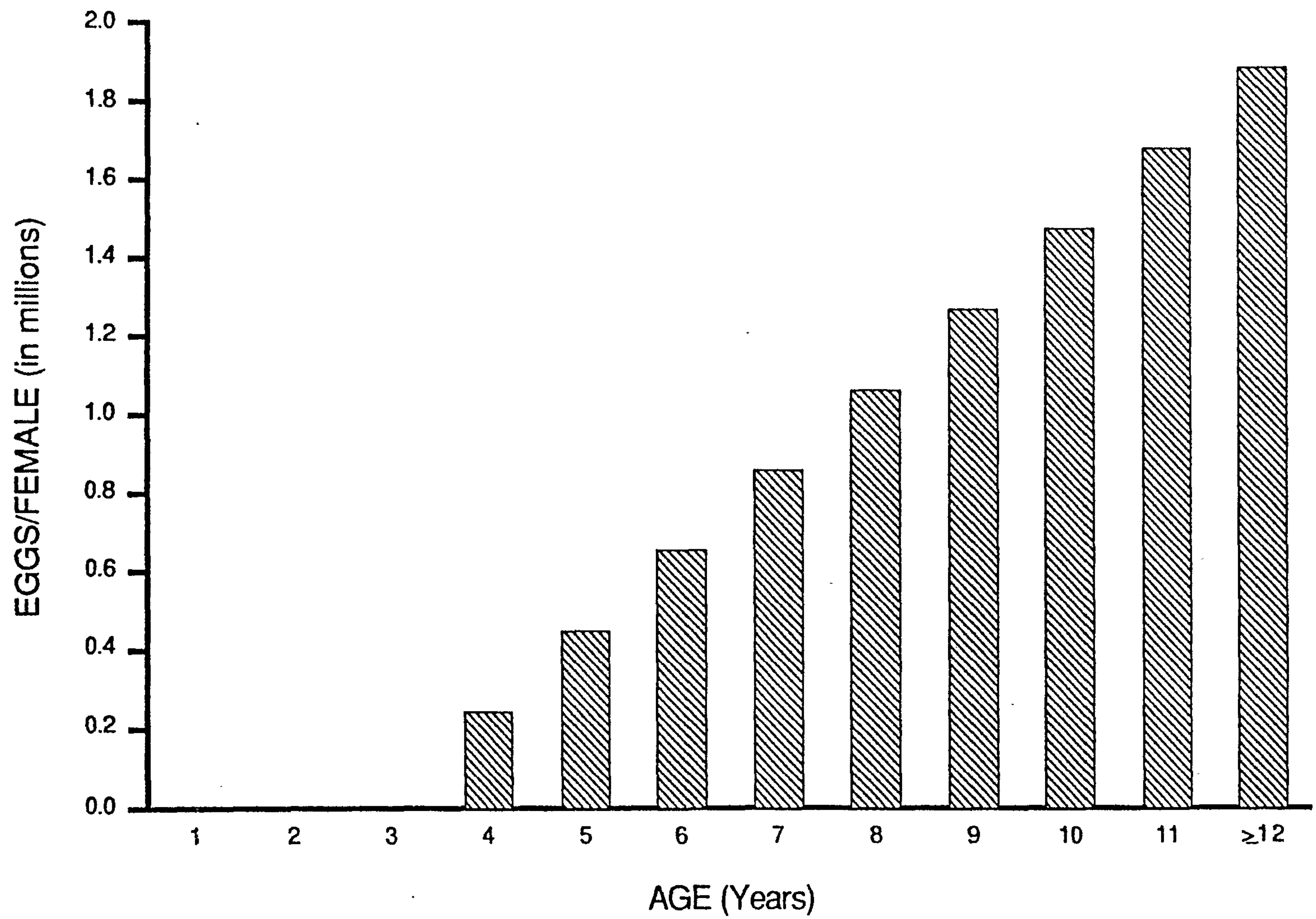

FIGURE 1. General relationship between striped bass age and fecundity (eggs per female).

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hatchery produced striped bass and their relative contribution to the fishery and the reproducing adult population.

Striped bass feed on a variety of organisms. Larval striped bass initially prey on small zooplankton such as copepods and cladocerans. Juvenile bass feed primarily on mysid shrimp (*Neomysis mercedis*) but also feed on other invertebrates such as amphipods and small fish.

Subadult and adult striped bass are opportunistic predators; they are piscivores, and the species eaten depends on what is abundant at the time. During spring and summer, northern anchovy is the most important prey for bass in the south and central Bay and in San Pablo Bay. Pacific herring is an important food item during the winter months when they enter the Bay to spawn. During the spring, salmon smolts are important in the diet of striped bass in the lower Sacramento River. The bay shrimp (*Crangon* spp.) and mysids are also important food items for yearling and older bass. Species of fish that are likely to prey on young bass in the Delta include catfish, largemouth bass, yellowfin goby, and older bass. Some invertebrates, such as mysids, shrimp (*Palaemon macrodactylus*), and certain copepods (e.g., *Cyclops* spp.), may also feed on larval striped bass.

Striped bass were initially the object of an intensive commercial fishery, which by 1903 harvested 2 million pounds per year. The catch remained stable until 1915 but declined thereafter, partly because of changing regulations. The commercial catch fluctuated between 450,000 pounds and 1 million pounds per year until 1935, when commercial fishing for striped bass in San Francisco Bay was banned, in part, because of conflicts between sport and commercial fisheries.

The striped bass sport fishery is one of the most important in the Bay-Delta. The number of striped bass caught by recreational anglers and the catch-per-unit-effort have declined over the past several decades. In recent years, angler harvest has ranged from approximately 100,000 to 400,000 striped bass per year.

STATUS OF THE STRIPED BASS STOCKS

The numbers of adult striped bass in the Bay-Delta population have shown a declining trend in abundance over the past two decades (Figure 2). Estimates of striped bass abundance based on the Department of Fish and Game mark-recapture program (referred to as Peterson estimates) indicate that the numbers of adult striped bass were relatively stable between 1969 when the estimates were first made and 1976. Between 1976 and 1977 the estimated numbers of adult striped bass declined from approximately 1.7 million fish (1969-1976 average) to approximately 1 million fish (1977-1984 average); a 40 percent decrease. Estimates of abundance based on the Department of Fish and Game adult striped bass tagging program (CPUE index) also show a decline in abundance.

The observed decline in the abundance of striped bass appears to be associated with an increase in the annual mortality rate of adult striped bass and a decline in the numbers of young bass produced and subsequently recruited to the adult population. The mortality rate of adult striped bass is a function of both sport fishing harvest and natural mortality. Although both fishing mortality and natural mortality are highly variable between years, the combined mortality rate for these two factors is approaching 50 percent per year.

The catch and catch-per-unit-effort (CPUE) in the striped bass partyboat fishery in the San Francisco Bay area provides additional information on trends in the striped bass population. The trend in both striped bass catch and CPUE (Figure 3) is consistent with the decline in the abundance of striped bass in the Bay-Delta.

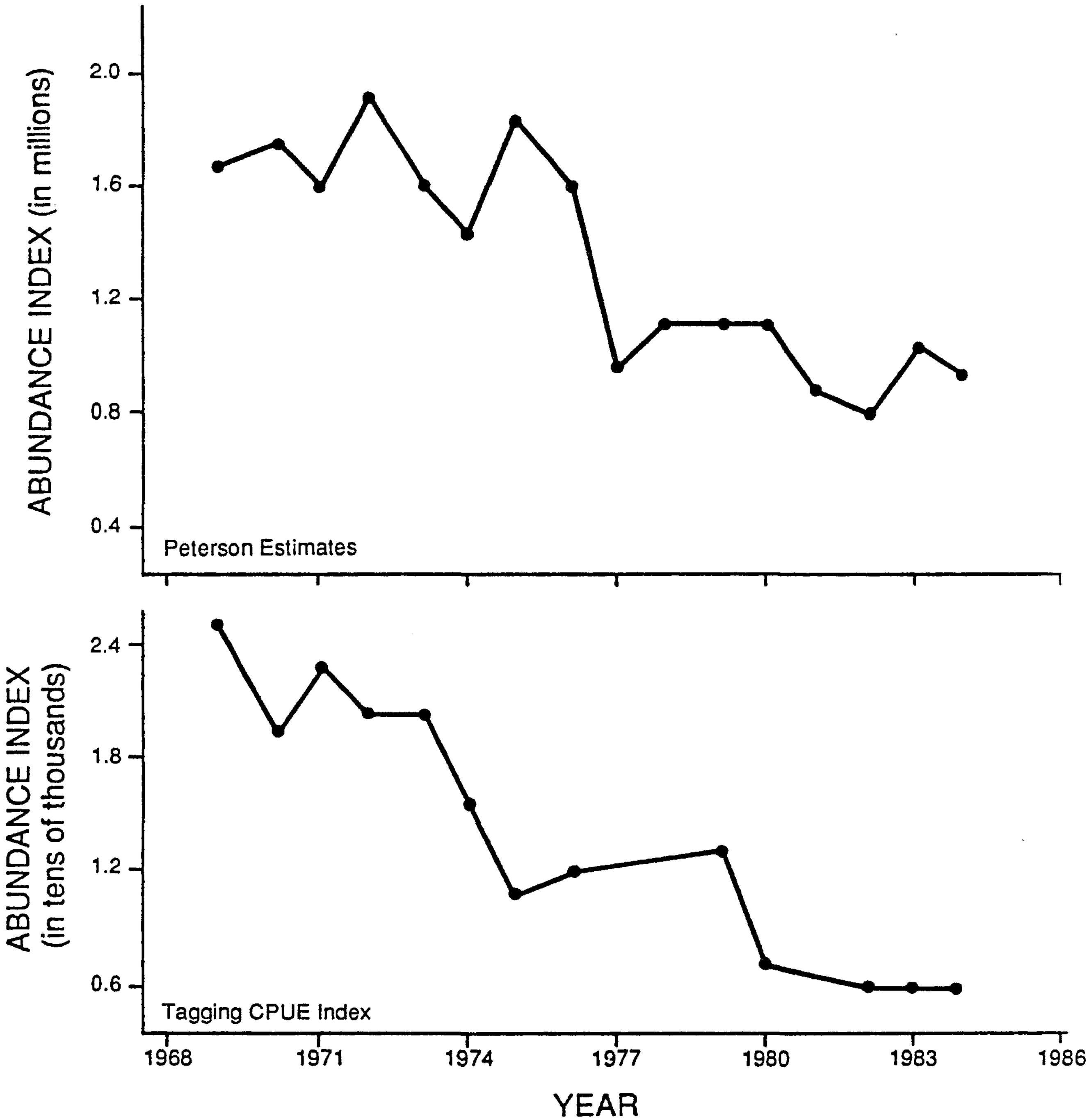


FIGURE 2. Estimated trends in the abundance of adult striped bass in the Bay Delta, 1969-1984 (Source: Stevens et. al., 1985).

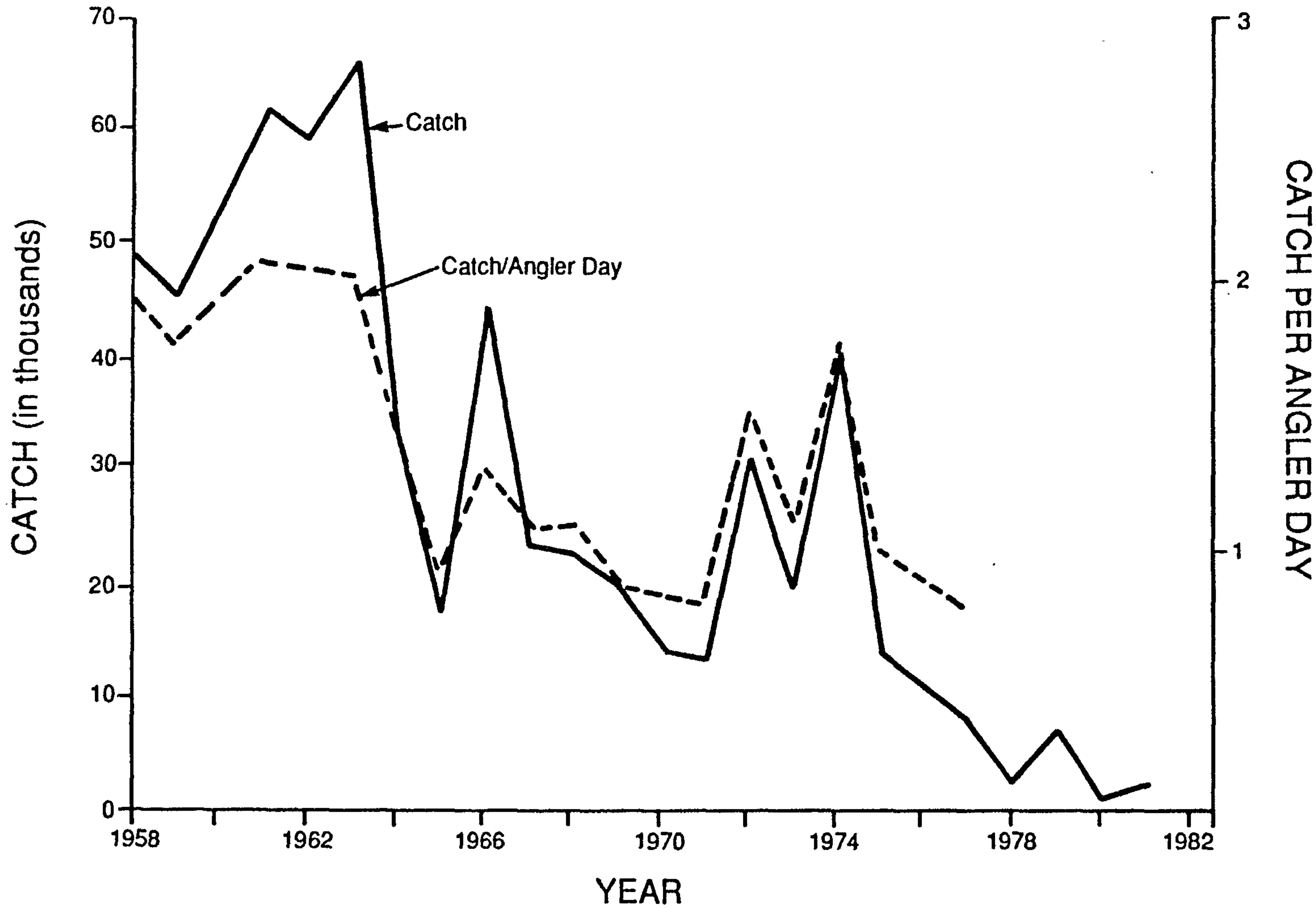
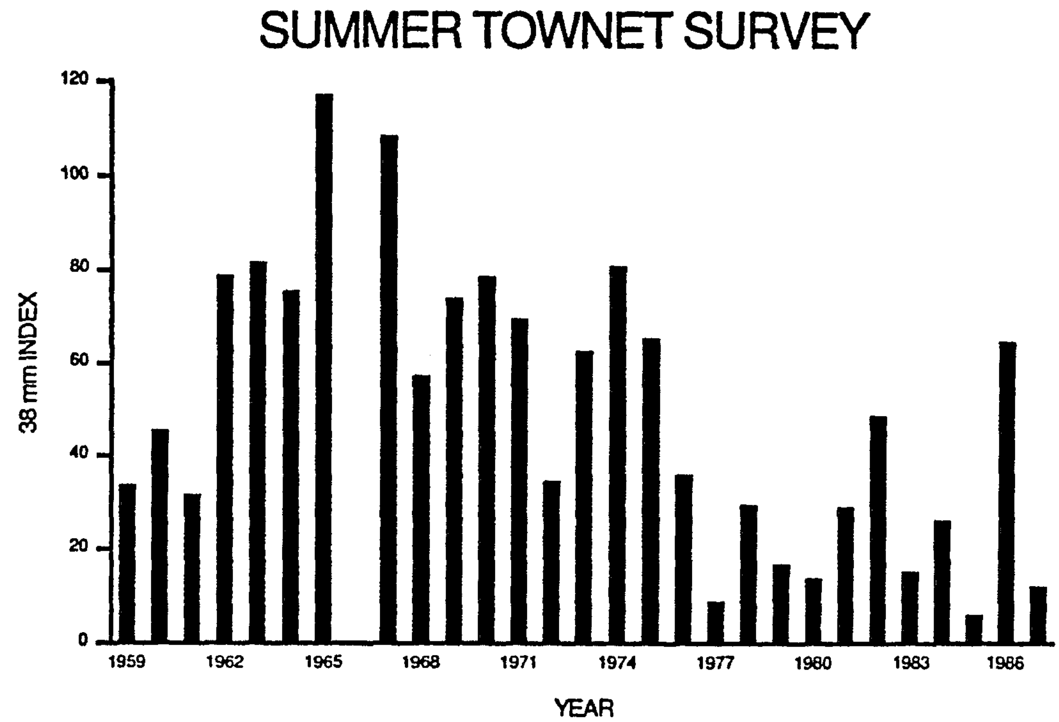


FIGURE 3. Trends in striped bass catch and catch per angler day reported by charter boats in the San Francisco Bay area.

The Department of Fish and Game has conducted a survey of the numbers of young striped bass (indexed at 38mm) produced each year between 1959 and 1987. The index appears to provide a good representation of abundance of juvenile striped bass, except in those years when high spring outflows distribute young striped bass into San Pablo Bay which is not included in the striped bass surveys. Trends in the index of year-class strength measured by the 38mm index (Figure 4) show that although the numbers of young bass produced each year has been highly variable, there has been a decline during the past decade.

Trends in the numbers of juvenile striped bass are also monitored by the Department of Fish and Game in surveys conducted during the fall (September-December). The estimated numbers of striped bass in the fall surveys (shown for the December surveys in Figure 4) are extremely variable. The correlation between the index of striped bass in the summer (38mm) and the fall survey are poor ($R = 0.22$ for the data shown in Figure 4). The low correlation makes it difficult to interpret the relationship between the striped bass index in the summer survey and survival to the subsequent fall survey.

Production of young striped bass has recently been augmented by bass reared in hatcheries and released as young-of-the-year and yearlings into the Bay-Delta. Striped bass, produced by private aquaculturists and the Department of Fish and Game, have been propagated during the past several years under the striped bass stamp fund and as part of an agreement between the Department of Fish and Game and Pacific Gas and Electric Company. The numbers of hatchery produced striped bass released into the Bay-Delta each year (Figure 5) exceeded one-million fish in 1986. The striped bass released as part of the hatchery propagation program are tagged so that an evaluation of their survival and subsequent contribution to the sport fishery and reproductive population can be assessed. Results of the hatchery assessment are not anticipated until 1990-1991. Although incomplete, preliminary



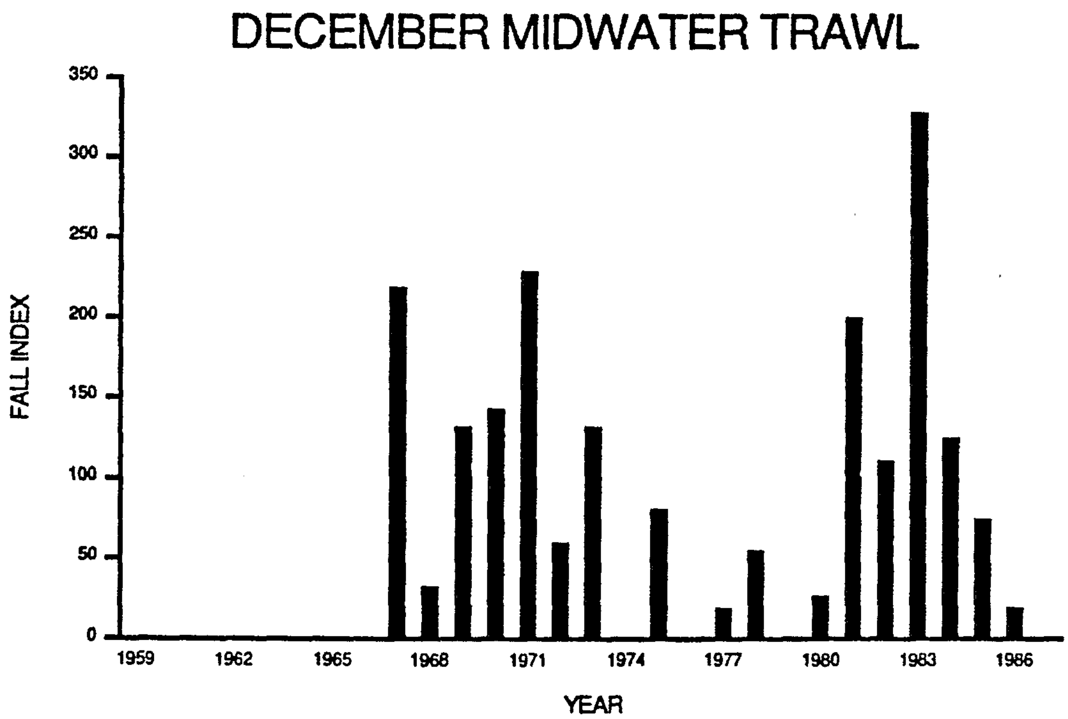


FIGURE 4. Striped bass 38mm index from the CDFandG summer townet surveys and the fall index from the December midwater trawl surveys.

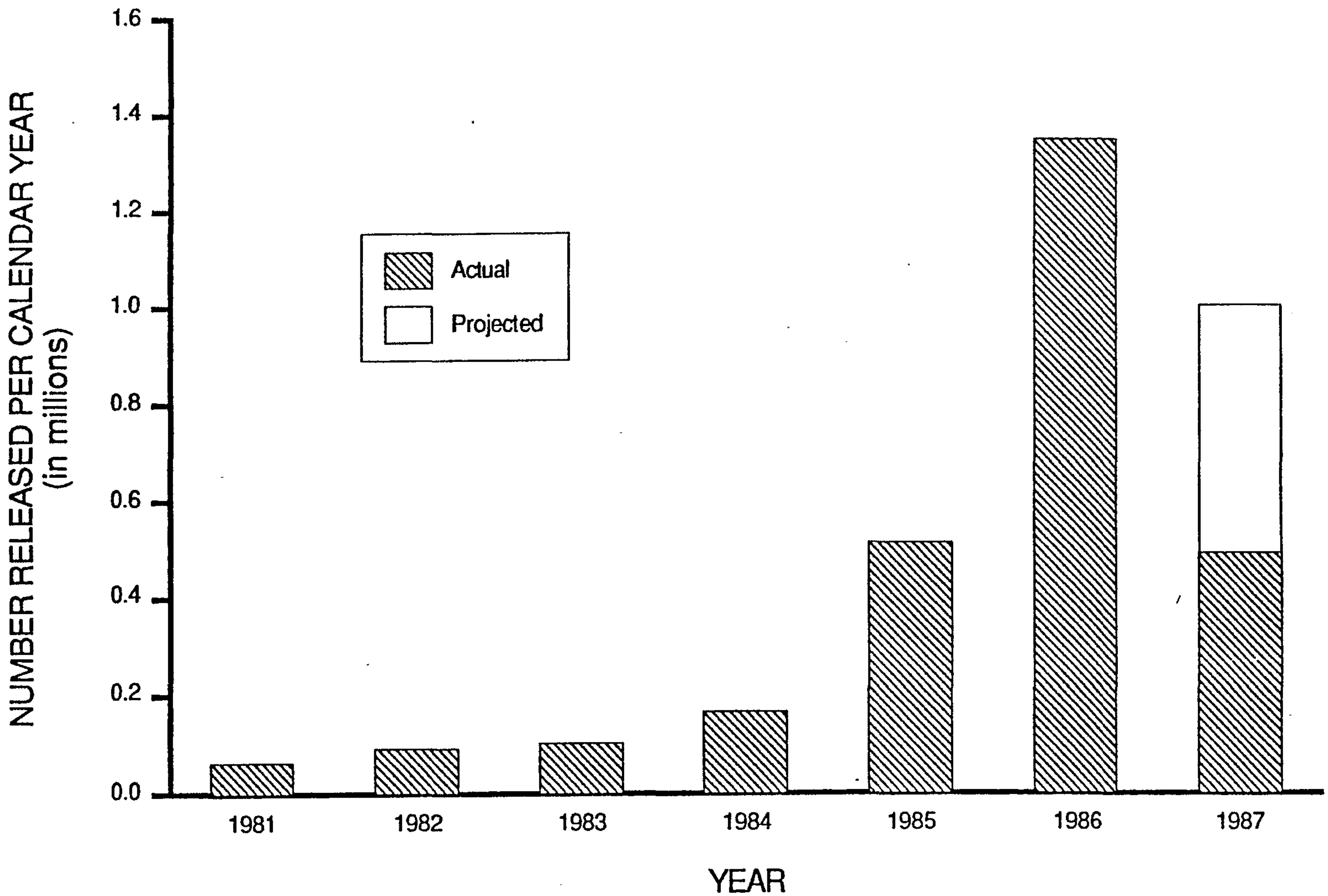


FIGURE 5. Number of hatchery reared striped bass released each calendar year into the Bay-Delta.

findings show that hatchery reared striped bass are contributing to the recreational fishery.

FACTORS AFFECTING STRIPED BASS

A wide variety of factors influence the growth and survival of young striped bass, recruitment to the sport fishery, and the number of spawning adults supporting the Bay-Delta bass stock. Five principal theories regarding the recent decline in the striped bass population are:

1. Reduced numbers of adults have resulted in reduced reproductive potential and hence reduced year-class strength (stock recruitment effects).

2. Availability of food resources (prey) necessary for growth and survival of larval and juvenile striped bass has declined.

3. Exposure to and accumulation of toxic compounds may be adversely affecting reproductive success and survival of larval, juvenile, and adult striped bass.

4. Entrainment losses of striped bass are occurring at a number of water diversion facilities, including within Delta agricultural withdrawals, withdrawals for industrial and municipal useage, and water exports.

5. Changes in Delta hydrology resulting from channelization and induced flow associated with water exports promote conditions in which young striped bass are transported into areas of the Delta where their survival is expected to be lower than that for striped bass in areas such as Suisun Bay.

The relative significance of each of these factors on the striped bass population varies from year to year. Some of the factors affecting striped bass stocks are briefly discussed below.

Reproductive Potential

Information available from monitoring programs conducted by the California Department of Fish and Game (CDFandG) indicate that declines in the adult striped bass population have resulted in decreased reproductive potential and hence reduced year-class strength.

The numbers of adult striped bass in the Bay-Delta population has declined over the past several decades (Figures 2 and 3). The decrease in the numbers of spawning adults, particularly the very large older females which produce large numbers of eggs, has resulted in a decrease in the numbers of eggs produced each year (Figure6). Reductions in egg production has been postulated as a significant factor contributing to the recent striped bass decline. Reductions in striped bass egg production could be contributing to reduced numbers of young bass produced each year and thereby reduced numbers of bass subsequently recruited into the recreational fishery and fewer bass entering the spawning population thereby contributing to further reductions in the reproductive capacity of the population.

A variety of factors have potentially contributed to the decline in the number of adult striped bass. Adult striped bass mortality is a function of natural mortality and mortality associated with fishing. Information collected by the National Marine Fisheries Service and CDFandG suggests that adult striped bass have body burdens of toxic chemicals that could be contributing to a direct reduction in reproductive potential through (1) increased mortality of adult striped bass and (2) reduced egg

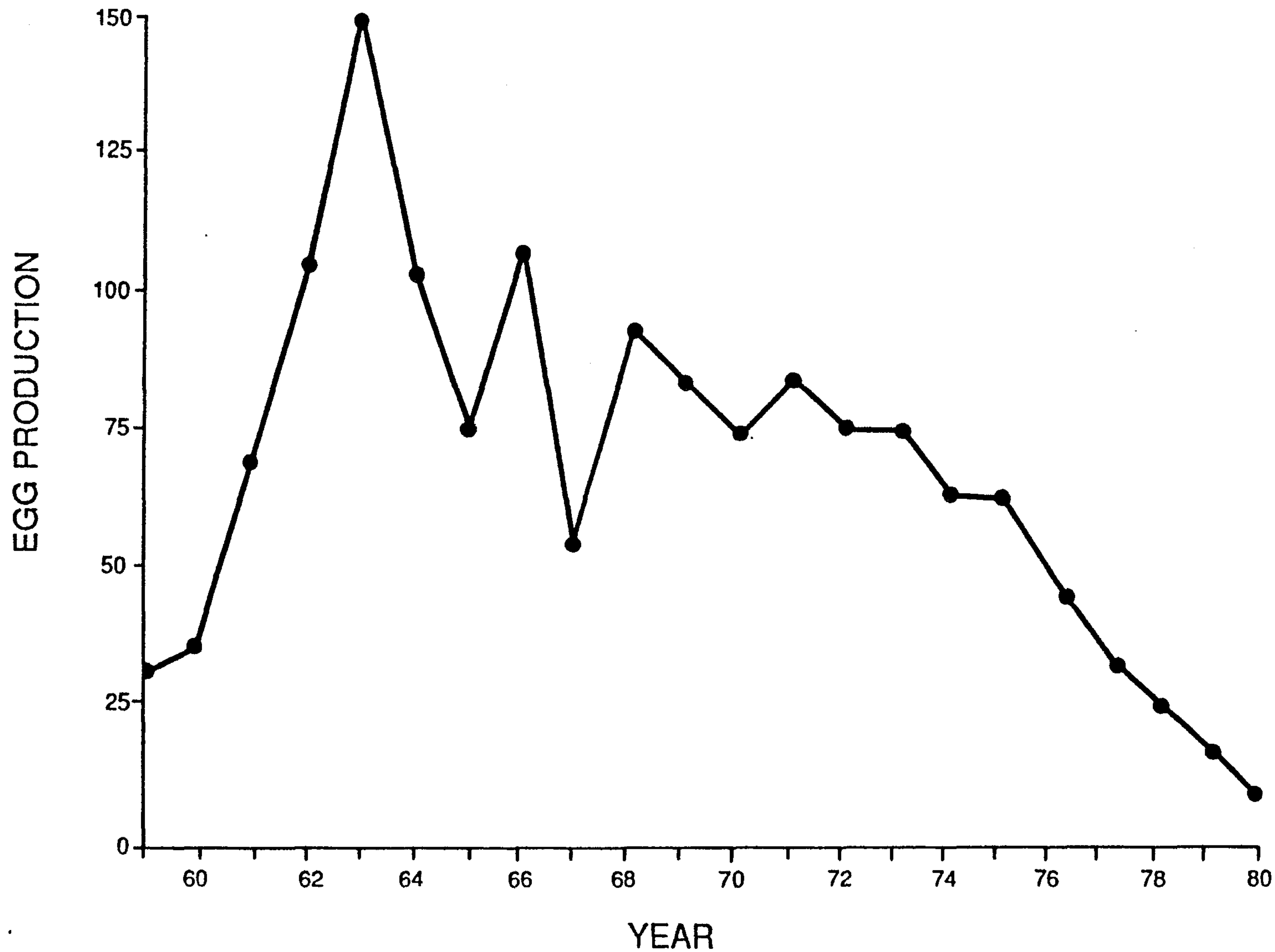


FIGURE 6. Egg production index for striped bass from 1959 to 1980 (Source: State Board Striped Bass Working Group, 1982).

production and egg viability. Fishing mortality resulting from both legal recreational harvest and illegal poaching activity contribute to a direct reduction in the numbers of spawning striped bass. The effect of fishing mortality on reproductive potential is in part the result of preferential harvest of the older larger fish in the population whose fecundity is very high relative to younger bass (Figure 1). In addition, a significant proportion of the fishing exploitation occurs during the spawning migration and on the spawning grounds where the fish are concentrated and therefore more susceptible to fishing pressure.

Food Supply

One hypothesis of the decline in striped bass suggests that primary and secondary production (phytoplankton and zooplankton, respectively) of the Delta environment has declined. The decline in Delta productivity may have resulted in an insufficient food supply (small zooplankton) necessary to support survival of larval and juvenile striped bass. The poor striped bass year-class strength observed during the late 1970's and 1980's may reflect, in part, the effects of a decline in the carrying capacity of the Delta environment resulting in the starvation of larval striped bass. Factors contributing to the apparent reduction in phytoplankton and zooplankton, the extent of the reduction, and subtle changes in species composition are not understood. Furthermore, the linkage between changes in the phytoplankton and zooplankton communities and the survival and growth of larval and juvenile striped bass has not been established.

Factors suggested as contributors to the decline in phytoplankton and zooplankton include the potential effect of increased water velocities in interior Delta channels associated with water exports which result in reduced residence time in these channels. The export of water with a high nutrient content, originating primarily in the San Joaquin River drainage, which is no longer available to support phytoplankton production in the Delta has also been suggested as a contributing factor. Speculation has also been given to the potential effects resulting from a major reduction in particulate organic loadings to the Bay-Delta system which occurred in the mid-1970's with the implementation of advanced sewage treatment facilities. The reduction in organic loading was coincident with the decline in phytoplankton, zooplankton, and striped bass production.

An alternative hypothesis suggests that phytoplankton and zooplankton production has not declined in recent years but that the abundance of these organisms has been depressed by increased foraging pressure from introduced fish species whose populations have experienced dramatic increases. Species such as the inland silverside have recently established populations in the Delta that have grown substantially in number, and may be cropping a large proportion of the production of the Bay-Delta system. Other recently established species such as the yellowfin goby, which is now very abundant, may not only compete with larval striped bass for food but subadult and adult gobies may be effective predators on larval and juvenile striped bass. The interactions among the complex and dynamic array of physical, water quality, and biotic variables that influence the availability of food for larval and juvenile striped bass are not yet understood.

Specific tests need to be devised and conducted when water supply conditions permit, so that hypotheses regarding factors controlling food supply can be evaluated. Although the results were inconclusive, one such test has been devised to examine the relationship between residence time in interior Delta channels, which varies as a function of water exports through the SWP and CVP, and the bloom of phytoplankton. This test case was established based on information developed from historic phytoplankton surveys and represented a specific testable hypothesis, the results of which could be evaluated with respect to a specific predicted phytoplankton response. This test case illustrates, by way of example, the design and approach to be used in subsequent evaluations of specific hypotheses developed as a part of this recommended program. This test case also identified institutional problems in the design, coordination, and implementation of such a testing program that need to be resolved before effective evaluation of specific alternatives can be completed in the future.

Toxics

The effects of exposure to and bioaccumulation of toxic chemicals on the striped bass population of the Bay-Delta are not yet well understood. Information has been compiled from studies of adult striped bass that show body burdens of toxicants and parasites are relatively high. Toxics could be contributing to both direct mortality of adults and reduced reproductive success. Available information on the potential effects of ambient concentrations of toxicants in the Bay-Delta on the hatching success and survival of striped bass eggs, larvae, and juveniles is incomplete and inconclusive. Information is needed on the loadings and concentrations of many of the toxicants of concern, their sources, and the mechanisms by which these chemicals could be affecting striped bass. Very little data is available to assess the historical trends in exposure of striped bass to potentially toxic chemicals. In addition, very little is known about possible indirect linkages between pollutant loadings (such as herbicides and pesticides, hydrocarbons, and heavy metals), and the production of phytoplankton and zooplankton in the Bay-Delta. Information on such linkages is important because phytoplankton and zooplankton form the trophic (nutritional) base for striped bass (and all other fish in the system).

Entrainment

Entrainment refers to the direct loss of fish at agricultural, municipal, and industrial water facilities. The majority of these facilities are unscreened providing no protection for fish encountering the withdrawal. Other diversion facilities are screened, however the effectiveness of existing fish protection measures varies considerably between sites and between fish species and life stage. Striped bass are most susceptible to entrainment during their early life stages as planktonic eggs and larvae which passively drift with the water currents. Striped bass eggs and larvae are small and simply pass through the mesh of intake screens and are lost from the system. Juvenile striped bass have the necessary swimming performance capability to avoid many of the diversions and can be effectively protected.

The largest number of diversion facilities are relatively small and unscreened. The facilities are used to supply water on a seasonal basis for agricultural irrigation. Many of the larger capacity diversion facilities are equipped with intake screens designed for debris removal (e.g., peat and other vegetation) and secondarily provide some degree of fish protection. The louvered intake structures at the Central Valley Project (CVP) and State Water Project (SWP) were designed, in part, to provide protection for juvenile striped bass. They have been partially successful in achieving this goal.

The numbers of striped bass lost each year as a result of entrainment at agricultural, municipal, and industrial diversion facilities is uncertain, although the available information indicates that entrainment losses are substantial. The significance of entrainment losses as a factor influencing year-class strength of striped bass has not been quantified. Regardless of the actual quantification of losses at each site, entrainment losses are sufficiently high to warrant development and implementation of a program designed to lower losses.

Improvements can be made in the physical design and operational pattern of Bay-Delta diversion facilities to reduce striped bass entrainment losses. Where entrainment losses continue to occur at major diversions, mitigation for those losses should be provided. Recent efforts by Pacific Gas and Electric Company, CDFandG and the Department of Water Resources provide examples of the type of positive actions necessary to address various aspects of the entrainment problem. Pacific Gas and Electric Company, which operates electric power generating stations at Pittsburg and Antioch, has implemented a program which has been demonstrated to significantly reduce striped bass entrainment losses. The California Department of Fish and Game and Department of Water Resources recently entered into an agreement which requires mitigation of direct entrainment losses of striped bass associated with operation of the SWP diversion facilities. The agreement executed by DWR and the Department of Fish and Game in December 1986, is presented as Appendix A of this report. This agreement addresses striped bass, steelhead, and salmon losses and provides the following:

- $15 million to initiate the program;

- About $2 million/year for measures directed first at protection of native stocks and secondarily at hatchery production.

Mitigation for native striped bass losses will be achieved under this agreement through hatchery production and facilities to "grow out" young striped bass salvaged at the SWP Skinner Fish Protection Facility located just upstream of the state pumping plant. These fish will be released back into the Bay-Delta system after they reach a size where they would have a relatively high probability of survival. In addition, some of the money will be spent to learn more about striped bass.

Delta Hydrology

The role of Delta hydrology in determining year-class strength for striped bass has been the subject of considerable study over the past several decades. Relationships have been hypothesized, for example, between freshwater outflow during the spring months (primarily May, June, and July) and the CDFandG 38mm index of striped bass abundance. This relationship produced relatively good predictions of the abundance of juvenile striped bass each year through 1976 (Figure 7). The previously good relationship between spring outflow and striped bass production, however, deteriorated during the late 1970's. With the exception of 1986, the relationship, which formed part of the basis for the D-1485 standards to protect striped bass, failed to provide accurate estimates of the 38mm striped bass index of abundance over the past decade (Figure 7). We do not understand the process through which outflow affects striped bass production or survival and have no clear explanation for the change in the outflow/striped bass relationship. We are not confident that specific new outflow criteria can be established at the present time which will protect and enhance the striped bass population.

Specific areas of interest with respect to Delta hydrology, as it pertains to striped bass include transport of water and incidental transport of striped bass eggs, larvae, and juveniles into the central Delta through the Delta cross-channel, Sacramento River outflow regimes, and the effects of SWP/CVP exports on reverse flows in the lower San Joaquin River.

Delta Cross-Channel Operation

The Delta cross-channel, located near Walnut Grove, provides a means for conveying water from the Sacramento River into the central Delta as part of the SWP/CVP operations. Concern has been expressed regarding the survival of striped bass eggs and larvae, spawned in the upper Sacramento River, which are diverted from the river into the interior Delta channels as a result of operations of the cross-channel during the spring. Striped bass eggs and early larvae are planktonic, passively

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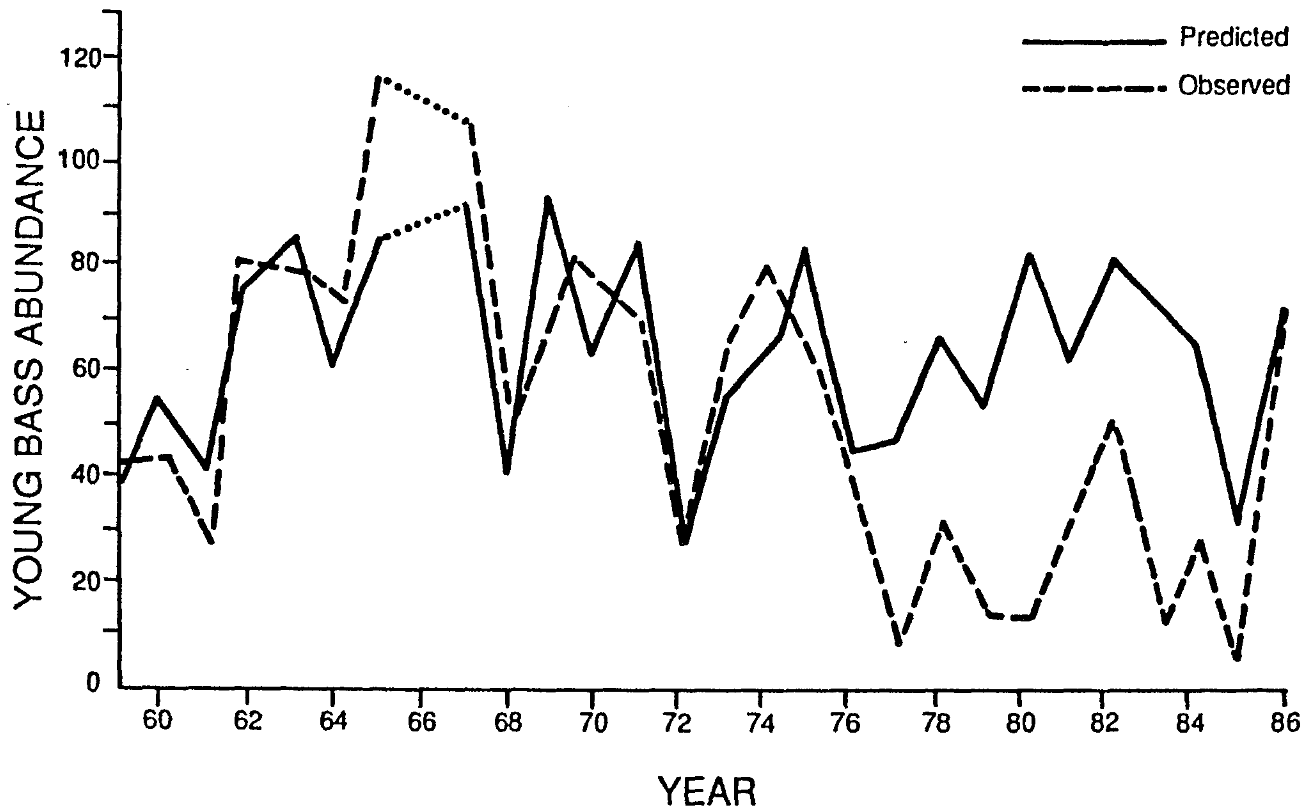
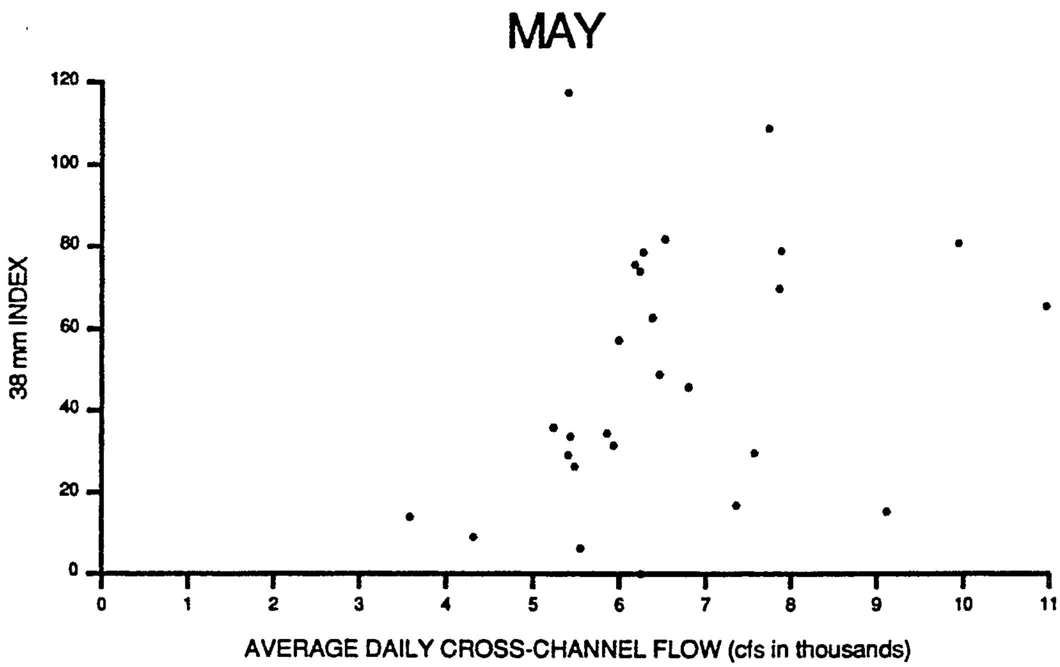


FIGURE 7. Trend in the observed striped bass 38mm index and the predicted index based on May-June diversion rates and outflows, 1959 to 1986.

drifting with the water currents, and are susceptible to being drawn (hydraulic entrainment) into the cross-channel.

Two potential approaches have been identified for reducing the numbers of striped bass diverted into the cross-channel. One approach is to install fish screens at the opening to the cross-channel. Striped bass eggs and larvae are small, however, and cannot be effectively excluded from the cross-channel by conventional screening techniques. The second approach involves reducing the flow passing through the cross-channel by closing the existing cross-channel gates during periods when striped bass eggs and larvae are passing the cross-channel entrance and are susceptible to hydraulic entrainment.

There has been speculation that survival rates are reduced for striped bass diverted into the central Delta by operation of the cross-channel as a result of increased susceptibility to entrainment at water intakes, increased susceptibility to predators, and reduced food supplies. Based on available information, it is difficult to evaluate the actual benefit the striped bass population might derive from reduced cross-channel operations. In a preliminary investigation, historic flows through the cross-channel and Georgiana Slough during May and June, the period when most striped bass eggs and larvae are in the river, were compiled to characterize flows from the Sacramento River into the central Delta. It was expected that, if cross-channel operation was a significant factor influencing striped bass year-class strength then, we would see evidence of strong year-classes in the years when cross-channel flows were lowest and weak year-classes when cross-channel flows were highest. A comparison of the CDFandG 38mm striped bass index and corresponding cross-channel flows (Figure 8) illustrates the problem of establishing and evaluating effectiveness of hydraulic scenarios. The cross-channel flow rates during May were greatest during 1974 and 1975, years in which striped bass year-class strength was relatively strong (38mm indices of 80.8 and 65.5), and flows were lowest in 1980, a



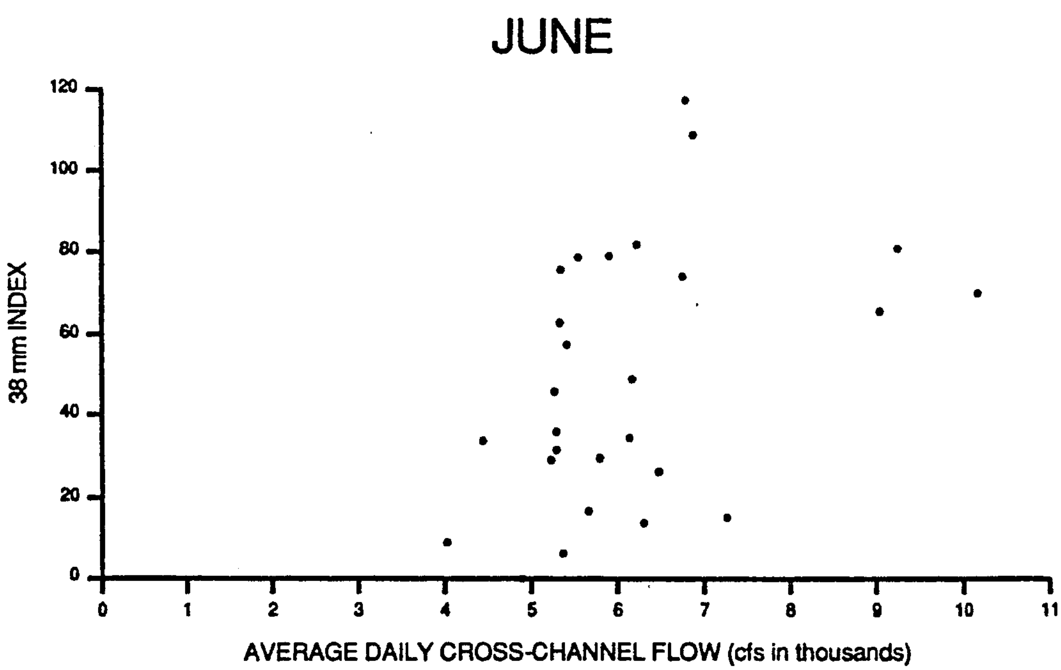


FIGURE 8. Relationship between flow into the Delta cross-channel and Georgiana Slough during May and June and the striped bass 38mm index, 1959 to 1985.

year when the 38mm index (14.0) was relatively weak. There is a need to establish a study program to evaluate the potential effectiveness of various scenarios for operation of the Delta cross-channel on year-class strength of striped bass.

In addition to evaluating the effectiveness of various cross-channel operating scenarios, there is a need to establish biological and operational criteria for determining the feasibility for reduced cross-channel operation based on a consideration of the water-year-type, Delta hydrologic conditions, export demands, and the presence of striped bass eggs and larvae in the vicinity of the cross-channel entrance. A hydrologic evaluation is needed to determine, on a water-year-type basis, the operational feasibility and constraints on periodic reductions in cross-channel flow. A biologic monitoring program is needed to determine on a year by year basis the temporal distribution of striped bass eggs and larvae in the Sacramento River for use in establishing a seasonal time frame for considering tests in which cross-channel flows are reduced when fish densities are greatest.

A preliminary investigation of the temporal distribution of larval bass has been made using data collected by CDFandG in the vicinity of the cross-channel. The temporal distribution of larval striped bass in 1984, 1985, and 1986 (Figure 9) is characterized by high variability between years. The density distributions are also characterized by a high variance between sampling days. For example, the striped bass density observed on 12 May 1986 of 0.06 larval bass/m^3 is a poor predictor of the density two days later on 14 May 1986 of 7.4 bass/m^3. Similarly, the peak density on 14 May 1986 (7.4/m^3) was followed on 16 May 1986 by a density of 0.15 bass/m^3. This information indicates that implementation of a test condition to reduce cross-channel flows when practical would need to include real-time monitoring information on the density distribution of striped bass eggs and larvae to determine when flow reductions would be most effective in reducing fish diversion and in quantifying the potential biological benefits associated with such a program.

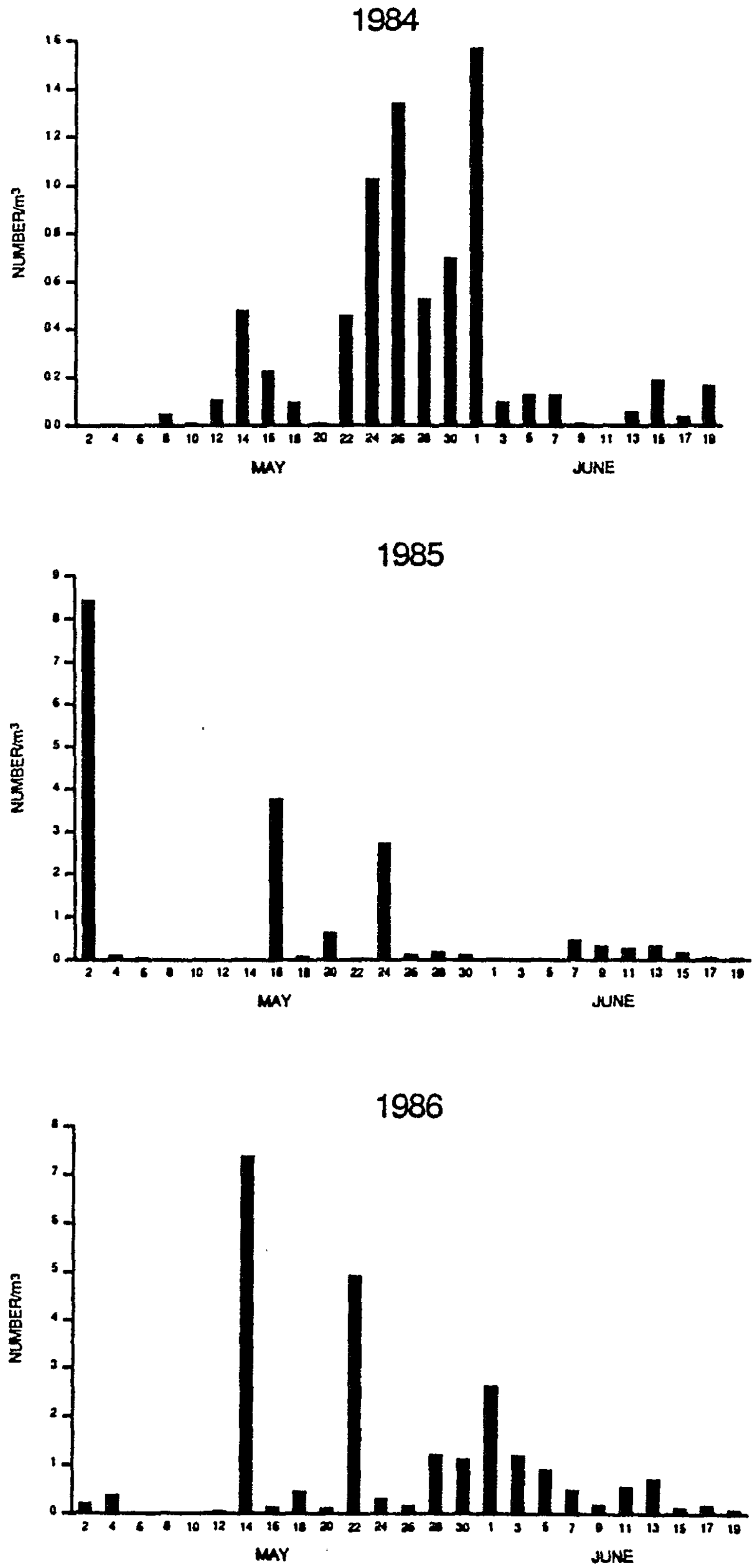


FIGURE 9. Temporal distribution in densities (no./m3) of 4-6mm striped bass larvae in the vicinity of the entrance to the Delta cross-channel (Source: CDFandG unpublished data).

Sacramento River Flows

The relationship between Sacramento River flow and the production and survival striped bass have been studied extensively during the past several decades. Historically, a relatively good correlation (not a cause-and-effect relationship) was found to exist between spring flows and the subsequent abundance of young striped bass. This correlation has deteriorated during the past ten years (Figure 7) thereby erroding our confidence in the basis for establishing specific, rigid flow criteria intended to protect and enhance a fishery resource such as striped bass.

The location of the entrapment zone in Suisun Bay and the western Delta varies in response to outflow conditions. The entrapment zone is an area of relatively high primary and secondary productivity. Larval striped bass also accumulate in the entrapment zone where survival rates are thought to be higher than for other areas of the Bay-Delta. Historic striped bass survey data indicate that striped bass year-class strength (38mm index) varied as a function of entrapment zone location. Striped bass year-class strength was typically greater in those years when outflows during May and June were such that the entrapment zone was located in Suisun Bay. Striped bass year-class strength was lower in years of lower spring outflows when the entrapment zone was located in the channelized regions of the western Delta. The unexplained changes in the relationship between striped bass year-class strength and spring outflows, which determine the location of the entrapment zone, during the last decade have led to uncertainty regarding the significance of the entrapment zone location as a factor influencing striped bass survival and year-class strength.

Establishing flow standards for the protection of striped bass is a very difficult process given the high variance and degree of uncertainty in the historic correlations between outflow and striped bass year-class strength. The agreement between the 1986 year-class index (38mm index 64.9) and that predicted based on the relationships used to establish the existing D-1485 standards (predicted index 65.0) is encouraging. We do not know, however, whether the agreement during 1986 signifies a recovery in the population or simply coincidence. Operations under the existing D-1485 standards with the addition of several recommended test scenarios, given the available water supply, will provide additional information necessary to evaluate the strength of the outflow standards in producing the predicted levels of striped bass before recommending further revisions to the standards. In the interim, specific information on the detailed size-specific distributions, relative abundances, and trends in mortality rates for striped bass larvae and juveniles in response to the controlled hydrologic flow regimes established to test and verify the effectiveness of alternative hydrologic/operational scenarios should be collected prior to recommending revisions to the existing flow standards. Consideration should be given to an evaluation of the significance of the entrapment zone location during May and June on the survival, growth, and year-class strength of striped bass.

San Joaquin River Flows

The relationship between reverse flows in the lower San Joaquin River and the distribution and survival of young striped bass, has been the subject of considerable debate. We strongly suspect that modification of flow patterns in the Delta, such as reversed flows in the lower San Joaquin River, are adversely affecting survival of larval and juvenile striped bass. During periods of time when the San Joaquin, Mokelumne, Calaveras, and Consumnes rivers and the Delta cross-channel and Georgiana Slough flows are less than the amount of water being used in the south and central Delta for agricultural irrigation and exports by the SWP and CVP, the flow of the lower portions of the San Joaquin River is reversed; water moves down the Sacramento River and back upstream into the San Joaquin River. Striped bass spawned in the Sacramento River and lower San Joaquin River, which passively drift with water currents during their early life stages, are transported into areas of the Delta by reversed flows where available food supplies are thought to be reduced and susceptibility to entrainment and predation is increased. These factors, although not well documented, would be expected to contribute to increased mortality and thereby reduced year-class strength for striped bass.

Results of a preliminary examination of the possible relationship between flow conditions in the lower San Joaquin River, both positive flows and reversed flow conditions, and historic estimates of survival rates for larval striped bass illustrates the problems with establishing flow criteria and objectives and subsequently evaluating the effectiveness of the standards for protecting species such as striped bass. Average flows past Jersey Point during May and June were compiled from Department of Water Resources dayflow records for the period from 1959 to 1985 to characterize flow conditions in the lower San Joaquin River during the months when larval striped bass would be most susceptible to reversed flow conditions. Flow conditions varied substantially between years (Figure 10) for both months. Flows were typically lower during June than during May and the frequency of reversed flows was greater during June (Figure 10). We expected that if reversed flows were a significant factor influencing the survival of larval striped bass then low survival rates should be detected in years when reversed flows were greatest and higher survival rates should be apparent when flows in the lower San Joaquin River were positive. We used the CDFandG 38mm striped bass index for comparison with flow conditions in the lower San Joaquin River. Results of this comparison are presented in Figure 11.

Based on available information, it is difficult to evaluate the actual benefit the striped bass population might derive from a reduction in the occurrence of reversed flows in the lower San Joaquin River. The use of relatively broad indicators, such as monthly average flows and the 38mm striped bass index, does not provide the necessary sensitivity to effectively test and evaluate the potential biological benefits

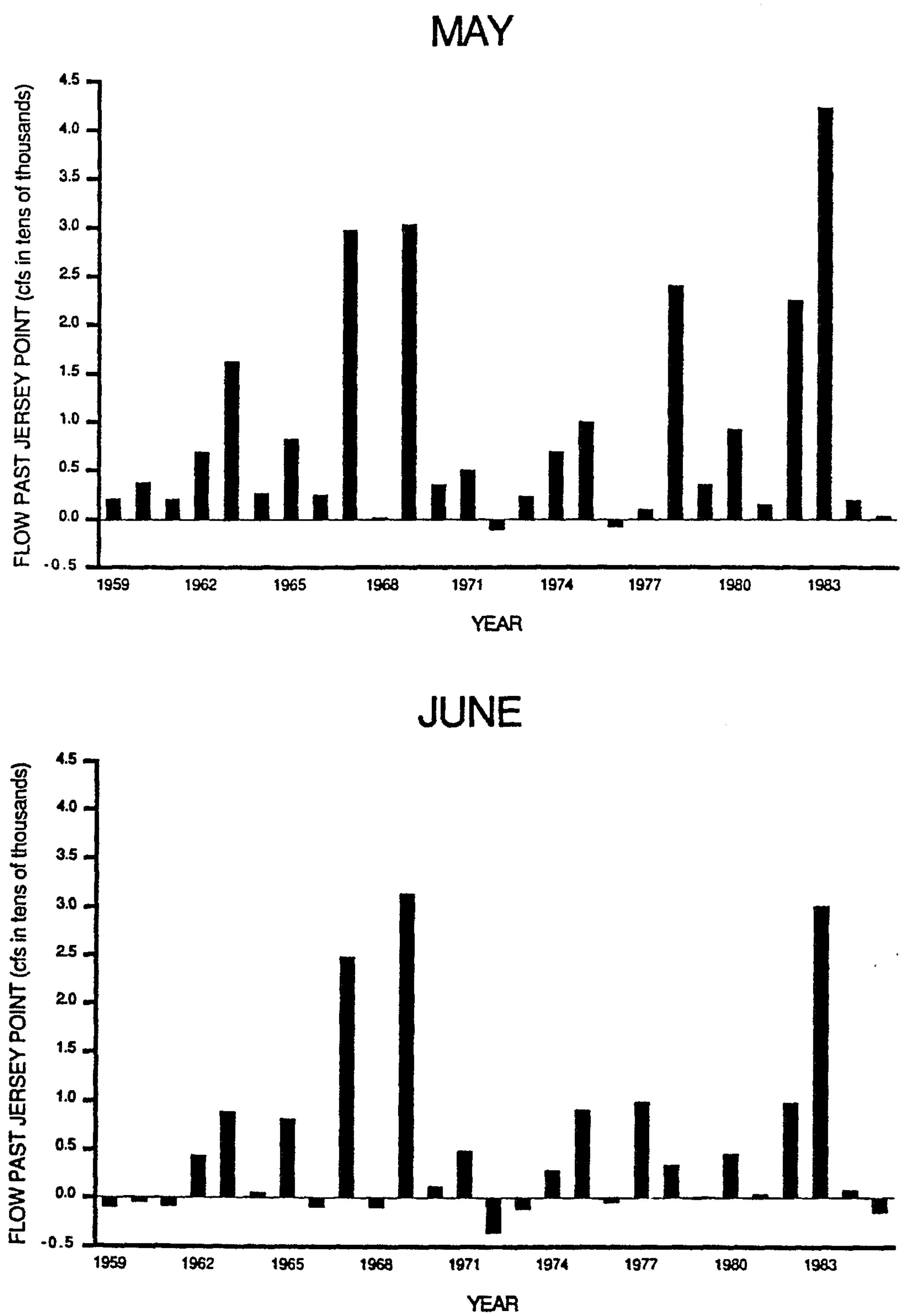
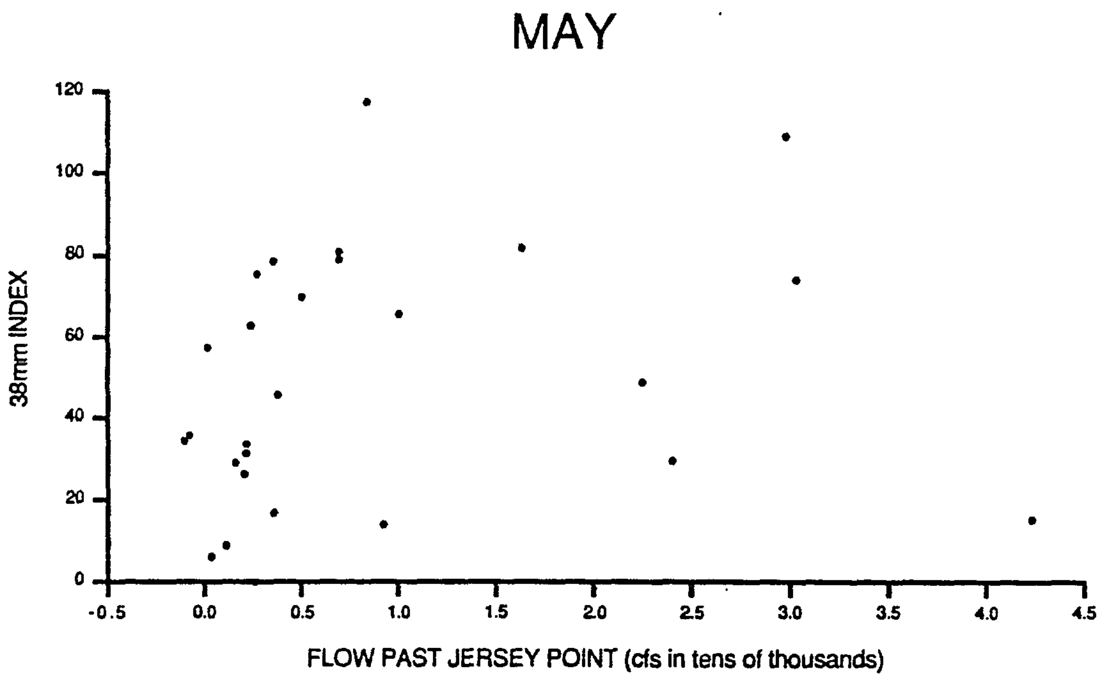


FIGURE 10. Average monthly flow past Jersey Point during May and June, 1959-1985.



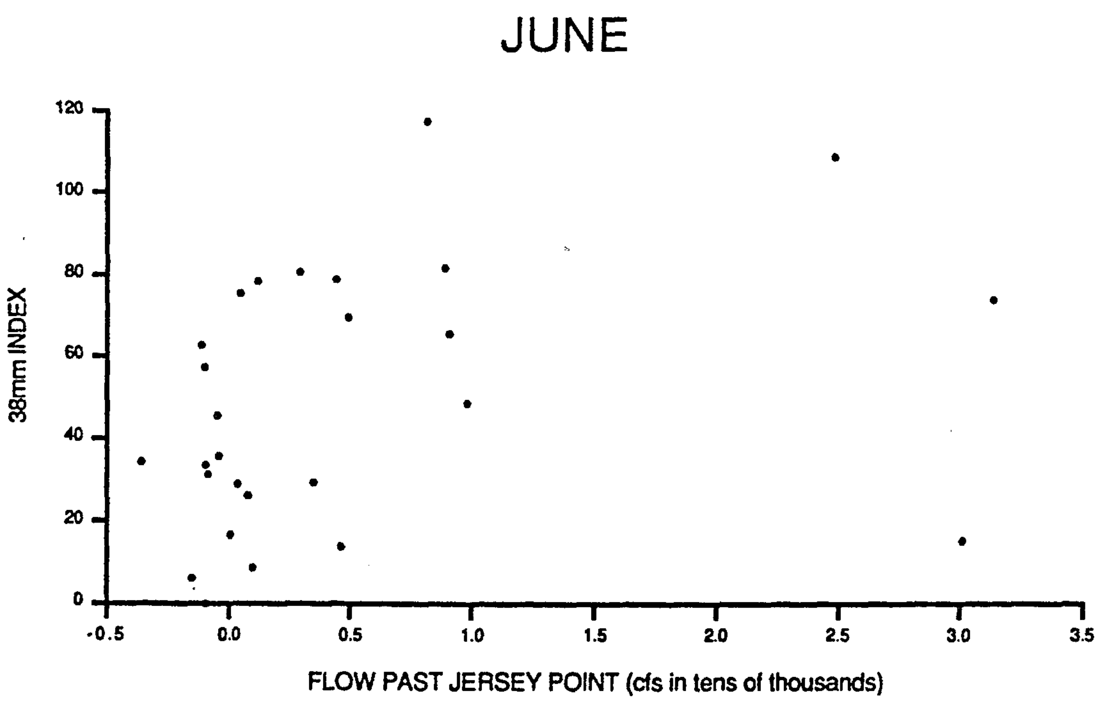


FIGURE 11. Relationship between the striped bass 38mm index and average daily flow past Jersey Point during May and June, 1959-1985.

associated with proposed hydrologic scenarios. Evaluating potential biological benefits associated with various hydrologic scenarios and other factors affecting striped bass has proven to be difficult and inconclusive. Much of the available biological information on the striped bass population has been collected in routine monitoring programs designed to characterize the general status of the population. A more rigorous effort is required to establish specific test conditions in advance, define the specific criteria to be used in evaluating potential biological benefits, and identifying specific data to be collected which will provide the necessary quantitative basis to effectively evaluate test conditions.

DISCUSSION

A comprehensive program is needed as a basis for defining and implementing the actions and standards necessary to accomplish the management of the striped bass stock. The goals of this program should:

1. provide near-term protections for the striped bass stock to reverse the declining trend in abundance;

2. provide conditions which are conducive to an increase, over the long-term, in the numbers of striped bass inhabiting the Bay-Delta system; and

3. meet these goals through a combination of measures that recognize and minimize impacts on other beneficial uses of Bay-Delta water.

There are many actions that can be taken to accomplish these goals. For each action, it is important that a plan be developed to evaluate and verify the actual benefit to the striped bass population. Some of these actions should be implemented on a near-term basis, while others involve development of a long-term program. They include:

- implementation of interim restrictions on the recreational harvest of striped bass which would include a slot size limit (lower and upper size limits) on striped bass to protect older, larger striped bass that provide a significant portion of the reproduction in the population, limits on the total number of bass an angler can harvest each year, initiation of a punch card reporting program, and promotion of the use of barbless hooks and catch and release sport fishing;

- increased enforcement efforts to reduce the incidence of illegal striped bass poaching;

- evaluation of existing hatchery-management practices and development of specific recommendations for improving hatchery production in terms of size of fish at release, genetics, release location, hatchery production objectives, and expansion of the existing hatchery planting program to help provide additional support in recovery of the adult population;

- construction of striped bass grow-out facilities for fish salvaged at the SWP;

- increased effort devoted to providing accurate monitoring information on the abundance, age structure, growth, condition, and survival of the juvenile and adult striped bass population, angler harvest, and the contribution of hatchery reared striped bass to the adult population to provide a basis for evaluating the effectiveness of interim actions and for recommending additional actions to be taken to ensure protection of adult striped bass;

- expansion of the data management efforts for all aspects of the program to provide efficient and rapid access to documented data bases which can be

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used to test various hypotheses and evaluate the potential effectiveness of various near- and long- term actions taken to meet the program goals;

- linkages between phytoplankton, zooplankton, and striped bass need to be defined and specific testable hypotheses established to provide a basis for examining relationships between factors such as Delta water quality or channel velocity and phytoplankton/zooplankton production;

- existing fishery surveys should be examined and critiqued to identify missing information that should be collected which would be useful in evaluating hypotheses and determining the effectiveness of each specific action taken to meet the program goals;

- monitoring of the health and condition of adult striped bass including the incidence of parasite infestation and body burden of toxic chemicals in specific tissues of the fish (e.g., gonads, liver, etc.) to provide a basis for assessing the overall health of striped bass, determining if potential health hazards exist associated with the consumption of adult striped bass, identifying and prioritizing the chemical toxicants that should be regulated more stringently, and providing a basis for evaluating improvements in the condition of the fish resulting from reductions in pollutant loadings;

- initiation of a detailed investigation of the viability of striped bass eggs and survival of larval and juvenile striped bass exposed to water quality conditions located in the major spawning and nursery areas;

- initiation of a detailed investigation of the potential effects of water quality conditions in various regions of the Bay-Delta on survival, growth, and production potential of phytoplankton and zooplankton that may be adversely effected by exposure to toxic chemicals (particularly agricultural pesticides and herbicides);

- evaluation of the significance of between-day variance in the Bay-Delta hydrologic regime should be included in biological and operational assessments of historic and planned hydrologic conditions. Rapid changes in the hydrologic regime of the Bay-Delta may play an important role in influencing the geographic distribution and survival of young striped bass that are obscured in analyses based on average monthly conditions;

- initiation of an integrated hydrologic testing program for conducting the necessary biological and operational evaluations to assess the effectiveness of various hydrologic scenarios in providing conditions favorable for striped bass. Existing data available from the striped bass survey programs should be evaluated to establish a set of potential flow scenarios, each with a specific expectation of striped bass survival or production, that can be evaluated under field testing conditions. In this way, striped bass year-class strength can be evaluated while maintaining sufficient operating flexibility to perform and assess the potential effectiveness of several recommended hydrologic scenarios in a coordinated fashion within the constraints imposed by available water supplies and demands; and

- evaluation of the available water supply in various water-year-types with the intent of minimizing the occurrence of reversed flow conditions in the San Joaquin River when reasonable. A complementary biological evaluation program should be established to collect necessary information to quantify the changes in the survival of striped bass attributable to the reduction in reversed flows.

Implementation of this program will require a high degree of cooperation among the participating parties. Evaluating the effectiveness of each hydrologic test condition will require extensive coordination and planning in terms of both the biological activities and the water supply/export levels which may limit or preclude testing in some years. Specific criteria need to be established in advance on the desired hydrologic condition and on the biological criteria which would serve to validate and quantify the biological benefits to striped bass. The State Board should establish a steering/advisory committee including representatives from various resources agencies, water project operators, the private sector, and recreational fishing interests to provide direction for this program, establish priorities for evaluations to be conducted, and monitor the findings of the program with the specific intent of developing recommendations for water quality and flow objectives to meet the goals of the striped bass program. The steering/advisory committee should be responsible for preparing an annual summary report to be presented to the State Board on the status of the near- and long-term program to protect the striped bass population and to set goals and priorities for the program. The steering/advisory committee would have responsibility for recommending actions to be taken in establishing or revising water quality objectives for striped bass during the trieannial review of the existing water quality control plan.

SUMMARY AND CONCLUSIONS

Striped bass were introduced to the Bay-Delta late in the last century. They thrived and today support an important recreational fishery in the Bay-Delta system. During the past several decades, there has been a decline in the numbers of adult striped bass. Great efforts have been made to understand why the decline occurred and how to correct it, but to date, the reasons for the decline are poorly understood.

There is general agreement that, while the mechanisms are poorly understood, operation of the state and federal water projects (SWP/CVP) has contributed to the striped bass problem. In recognition of this, the Department of Water Resources agreed to mitigate for striped bass losses that occur at its Delta Pumping Plant. The agreement was executed by DWR and the Department of Fish and Game in

December 1986. This agreement addresses striped bass, steelhead, and salmon losses and provides the following:

- $15 million to initiate the program;
- About $2 million/year for measures directed first at protection of native stocks and secondarily at hatchery production.

Mitigation for native striped bass losses will be achieved under this agreement through hatchery production and facilities to "grow out" young striped bass salvaged at the SWP Skinner Fish Protection Facility located just upstream of the state pumping plant. These fish will be released back into the Bay-Delta system after they reach a size where they would have a relatively high probability of survival. In addition, some of the money will be spent to learn more about striped bass.

A similar agreement for striped bass hatchery production was reached by CDFandG and Pacific Gas and Electric Company (PGandE) in 1983. Negotiations have begun for an agreement with the Bureau of Reclamation covering striped bass losses at the federal pumping plant (CVP). These agreements will provide substantial near-term support for the striped bass stock. However, these agreements, by themselves, will not result in long-term restoration of the native striped bass population.

There appear to be numerous factors other than operation of the SWP/CVP affecting striped bass. The factors include declines in reproductive potential and food supplies, exposure to toxics, and entrainment losses. There is a marked lack of consensus among experts as to the relative importance of these factors. There is, however, general consensus that modification of patterns of flow in the Delta and out of the Delta into Suisun Bay (Delta outflow) are important. Delta outflow controls the location of the entrapment zone, and outflow standards were included in D-1485 for this reason. The patterns of flow in the Delta (including Delta cross-channel flow and periodic reverse flow in the lower San Joaquin River) were also addressed in D-1485. However, without construction of facilities, correcting the cross-channel and reverse flow problems would require severe curtailment of SWP/CVP exports and would result in larger shortages for the state and federal projects water users. The State Water Contractors, the Department of Water Resources, and numerous others have made great efforts to gain approval to build facilities to correct this problem without success. Of all of the options for facilities, fishery experts are in general agreement that the Peripheral Canal is the best technical solution to the problem of flow patterns in the Delta. However, it would be premature, at this time, to recommend a specific solution. Instead, as recommended below, a series of comprehensive studies should be undertaken to verify this consensus or to determine if some other type of Delta facility would be more desirable.

Summary

The striped bass situation seems to be as follows:

- The decline of striped bass that began several decades ago has been even sharper in the last decade.

- We now know that we can grow striped bass in hatcheries. (Hatchery production is about 1 million fish per year). We did not know this when D-1485 was adopted. The ability to grow large numbers of striped bass in hatcheries is a major change in the striped bass situation.

- Despite numerous studies of the striped bass problem since D-1485, there is little consensus among experts about the relative importance of various factors that appear to contribute to the problem.

- We now have agreements providing for the mitigation of losses of striped bass at the SWP pumping plant and the PGandE power plants at Antioch and Pittsburg.

- We strongly suspect that modification of flow patterns in the Delta is adversely affecting survival of larval and juvenile striped bass.

- We know that changing flow patterns without construction of Delta facilities would severely reduce the water available to both projects water users (and, possibly, other water rights holders).

- We know that the Peripheral Canal or other Delta facilities would markedly improve the flow patterns in the Delta.

Conclusions

We conclude the following:

1. THE EXISTING MITIGATION AGREEMENTS PLUS THE YET-TO-BE-NEGOTIATED AGREEMENT ON THE CVP PUMPING PLANT PROVIDE REASONABLE PROTECTION FOR THE STRIPED BASS FISHERY AS AFFECTED BY THE DIRECT LOSSES AT THE CVP AND SWP DELTA PUMPING PLANTS AND PGANDE POWER PLANTS;

2. IN THE NEAR-TERM, ADDITIONAL SIGNIFICANT IMPROVEMENT CAN ONLY BE REASONABLY PROVIDED WITH SOME DEGREE OF CERTAINTY BY PRODUCING BASS IN HATCHERIES;

3. CORRECTION OF PROBLEMS ASSOCIATED WITH FLOW PATTERNS IN THE DELTA WITHOUT SEVERE IMPACTS ON THE PROJECTS

WATER USERS CAN ONLY BE PROVIDED BY CONSTRUCTION OF DELTA FACILITIES; AND

4. EFFORTS TO FIND OUT WHAT IS WRONG WITH STRIPED BASS HAVE GENERALLY BEEN INCONCLUSIVE AND PROVIDE LITTLE BASIS FOR THE SETTING OF NEW STANDARDS FOR STRIPED BASS.

Based on these conclusions, we recommend the following:

1. UNTIL THERE IS ADEQUATE TECHNICAL BASIS FOR NEW STRIPED BASS STANDARDS, THE D-1485 STANDARDS SHOULD REMAIN IN EFFECT;

2. NEAR-TERM STEPS SHOULD BE TAKEN TO INCREASE THE NUMBERS OF STRIPED BASS. HATCHERY PRODUCTION SHOULD BE THE PRIMARY MEANS OF PROVIDING THIS INCREASE;

3. COMPREHENSIVE STUDIES SHOULD BE INITIATED TO PROVIDE ADEQUATE TECHNICAL BASIS FOR REVISING D-1485 STANDARDS AND TO ESTABLISH A FIRM BASIS FOR RECOMMENDING THE APPROPRIATE DELTA TRANSFER FACILITY. THE STUDIES SHOULD ADDRESS THE TOPICS LISTED IN THE DISCUSSION SECTION. THE SWRCB SHOULD ASSEMBLE A MULTIDISCIPLINARY TASK FORCE TO MANAGE THE COMPREHENSIVE STUDIES;

4. BASED ON RESULTS OF THESE STUDIES, THE SWRCB SHOULD CONSIDER REVISION OF THE D-1485 STRIPED BASS OBJECTIVES AT EACH TRIENNIAL REVIEW OF THE BASIN PLAN; AND

5. DELTA TRANSFER FACILITIES SHOULD BE BUILT TO PROVIDE A LONG-TERM SOLUTION TO DELTA FLOW PATTERNS THAT ADVERSELY AFFECT THE STRIPED BASS POPULATION.

APPENDIX A

AGREEMENT BETWEEN THE
DEPARTMENT OF WATER RESOURCES
AND THE
DEPARTMENT OF FISH AND GAME
TO OFFSET DIRECT FISH LOSSES IN RELATION TO THE
HARVEY O. BANKS DELTA PUMPING PLANT

AGREEMENT BETWEEN
THE DEPARTMENT OF WATER RESOURCES
AND
THE DEPARTMENT OF FISH AND GAME
TO OFFSET DIRECT FISH LOSSES IN RELATION TO
THE HARVEY O. BANKS DELTA PUMPING PLANT

THIS AGREEMENT is entered into by and between the Department of Water Resources, hereinafter referred to as "Water Resources", and the Department of Fish and Game, hereinafter referred to as "Fish and Game", to offset direct losses of striped bass, chinook salmon and steelhead caused by the diversion of water by the Harvey O. Banks Delta Pumping Plant (Pumping Plant).

RECITALS

Water Resources and Fish and Game recognize:

A. Fish populations of the Sacramento-San Joaquin Delta (Delta), some of California's most valuable resources, are declining. Striped bass populations dependent upon the Delta have been declining since the 1960's. Today, California's native chinook salmon resource is extremely dependent upon the Sacramento River System. Fall runs of chinook salmon stocks in the Feather and the American Rivers are in good condition due to habitat maintenance, hatchery production, and stocking procedures. Other fall runs of chinook salmon in the Sacramento System have been depleted to varying degrees. Winter and spring runs of chinook salmon are severely depleted. Salmon stocks in the San Joaquin System are depleted more than stocks in the Sacramento River System. Steelhead stocks in the Sacramento

System are depressed. Other species of fish which are dependent upon the Delta have been adversely affected, but none of them appear to be endangered as a species.

B. Fish populations in the Delta are greatly influenced by a number of complex interactions, no one of which has been identified as the principal environmental factor. Delta inflow, water exports, power plants, consumptive uses, upstream and local diversions, tidal action, levee failures, pollution, agricultural return flows and recreational and commercial activities are all recognized factors that to varying degrees affect the fish resources of the Delta.

C. Overall fishery resources dependent upon the Delta have been adversely affected by impacts of flow distributions in the Delta caused by the State Water Resources Development System (which includes what is commonly called the State Water Project) and other water resource development projects. The State Water Project must mitigate for its impacts on fishery resources. This agreement covers only some of the impacts of the State Water Project.

D. The purpose of this agreement is to offset direct losses of some species of fish caused by the State Water Project Pumping Plant diversions. Direct losses are defined as losses of fish which occur from the time fish are drawn into Clifton Court Forebay until the surviving fish are returned to the Delta. These losses occur in spite of fish screens located at the Pumping Plant because of such things as enhanced predator efficiency in parts of the system, very poor screening efficiency for fish less than about one inch long, and mortality caused by handling fish in the salvage process. Direct losses of fish have reduced the abundance of affected species. Since these species are less abundant, the direct losses of these species in any given year are now likely less than they would be if water diversions in previous years had not occurred. An attempt to take this factor into account was made in defining responsibilities under this agreement. The parties do not intend to cover in this agreement losses which occurred prior to 1986.

E. Other adverse fishery impacts related to State Water Project operations need to be addressed. The parties intend to begin discussions on developing ways to offset these impacts which are not covered in this agreement, including facilities needed to offset fishery impacts and provide more efficient conveyance of water. The parties intend to continue the process which led to this agreement. That process included an advisory committee of representatives from interest groups concerned with fish resources affected by the State Water Project including representatives of the State Water Project contractors. Additional measures for impacts not covered in this agreement will have to be included in proposals by Water Resources to expand its diversions beyond the limitations contained in this agreement and will be part of agreements between Fish and Game and Water Resources regarding such proposals. Until agreement is reached on such measures, the State Water Project will not increase its diversions beyond those set forth in the U.S. Corps of Engineers Public Notice 5820A, amended, dated October 13, 1981 which limits exports to the amount of water that can be diverted by the existing pumps, except during winter months when additional amounts can be diverted during high San Joaquin River flow periods.

F. In principle, Fish and Game and Water Resources intend this agreement to offset direct losses of all fish caused by the diversions of water by the Pumping Plant starting in 1986. Presently however, information on impacts and measures to offset those impacts is sufficient only to deal with chinook salmon, steelhead and striped bass. Impacts on other species of fish will be addressed if impacts are identified and measures can be developed which would offset such impacts. Measures provided under this agreement may benefit other fish species.

G. It is the intention of Fish and Game and Water Resources to give priority to measures which are designed to protect or improve fish habitat and which would preserve the genetic diversity of fish stocks in preference to hatchery and stocking programs.

AGREEMENT

NOW THEREFORE, Water Resources and Fish and Game agree as follows:

I. Beginning in 1986, Water Resources will offset direct losses of striped bass, chinook salmon, and steelhead caused by the diversion of water by the Pumping Plant in the following manner:

A. Direct losses of striped bass, steelhead and chinook salmon caused by the Pumping Plant shall be determined annually each calendar year starting in 1986. The procedure used to calculate these losses is outlined in Appendix A. This procedure shall be revised by mutual agreement as better information becomes available.

B. The parties recognize the probability that direct losses of striped bass, steelhead and chinook salmon for any given year would be greater had there not been direct losses caused by the Pumping Plant in previous years. Calculation of such losses is not possible with existing knowledge. Therefore, Water Resources agrees to provide $15,000,000 to initiate a program which will increase the probability of quickly demonstrated results. The monies in this fund are in addition to the compensation for annual losses described in Section I.A. This payment is not intended to cover losses which occurred prior to 1986.

C. Commencing in 1986, Fish and Game will, following approval from Water Resources, undertake measures to compensate for the fish losses identified in Sections I.A and to provide the program set forth in Section I.B. Measures shall be selected in accordance with Sections I.D, I.E and I.F.

D. The following guidelines will be used in determining which measures shall be implemented.

1. Selection of such measures shall be based upon the following:

a. the magnitude of potential benefits;

b. evidence of the probability of achieving the benefits;

c. the costs (capital, operation, maintenance and replacement costs) of the measure in relation to other measures and to the expected benefits;

d. the ability and the cost to evaluate the success of the measure; and

e. environmental considerations.

2. Although it is recognized that hatchery operation can be an integral feature of any restoration program, priority shall be given to habitat restoration and other nonhatchery measures which help to protect the genetic diversity of the stocks and to avoid over reliance upon hatcheries. Where hatcheries are chosen, wild brood stock will be used.

3. In selecting salmon measures, priority will be given to measures on the San Joaquin River system.

4. The sum provided in Section I.B. shall be expended over a period of not less than five nor more than ten years from the date of execution of this agreement.

5. It is expected that obligations set forth in Section I.A. shall be met as soon as is practicable after they are incurred. However, compensation for these obligations may be accumulated over a period of years or spent in advance on the expectation of losses. Compensation for those obligations may be accumulated over a period of no more than ten years. Expenditures made in advance shall not exceed the obligations expected for the next ten years.

6. The average amount paid for fish replaced pursuant to Section I.A. shall not exceed the cost of replacing fish with hatchery reared yearling fish. Currently replacement costs are estimated to be $1.65 per striped bass and $.55 per steelhead and per yearling salmon. These costs will be adjusted yearly based on evidence of changes in hatchery production costs. During the reviews provided for in Section VI, progress on replacing fish will be reviewed to determine whether this limitation on expenditures is unreasonably constraining the ability to meet the guidelines provided in Section I.D. of this agreement. If so, the limitation on expenditures will be renegotiated.

E. Among the measures to be considered first will be those of Appendix B. At least one measure will be started in 1987. The consideration of the remaining measures in Appendix B will be completed by December 1988.

F. Fish and Game and Water Resources will jointly appoint and seek input from an advisory committee during the estimation of losses pursuant to I.A. and identification, selection and implementation of measures pursuant to I.C. and D. That committee will consist of interest groups concerned with fish resources affected by the State Water Project, including but not limited to representatives of commercial and sports fishing organizations and representatives of agencies which contract for water from the State Water Project. The process to be followed with regard to any given proposal for measures shall be:

1. The staffs of Fish and Game and Water Resources shall evaluate each proposed measure following the guidelines set forth in Section I.D..

2. The proposal will be submitted to the advisory committee.

3. The proposed measure may be modified based on input from the advisory committee.

4. Recommendations from the staffs and the advisory committee will be presented to the Directors of Fish and Game and Water Resources for a decision.

II. By December 1990, Fish and Game will evaluate the stocking of striped bass to determine the contribution of stocked fish to the fishery using various stocking strategies. Water

Resources will reimburse Fish and Game annually for 30 percent of the cost of the evaluation or $50,000, whichever is smaller, plus $5,000 per 100,000 fish marked of those stocked pursuant to this agreement. Both costs will start with fiscal year 1986-87 and will be adjusted annually based on annual percent increases in the average State employee compensation rates. Monies from the Striped Bass Stamp Fund may be used for this evaluation program, but other monies from the Fish and Game Preservation Fund will not be used.

III. Water Resources and Fish and Game may implement a mutually acceptable plan to reduce fish losses by predation in Clifton Court Forebay. Fish and Game will evaluate the effects of the plan and the losses computed under Section I.A. will be reduced to the extent that predation losses are reduced.

IV. When water is being diverted through the Pumping Plant, the John E. Skinner Delta Fish Facility (Skinner Facility) will be operated according to the following procedures:

A. Records satisfactory to Fish and Game will be maintained by Water Resources of the numbers, sizes, and kinds of fish salvaged, water export rates, and Skinner Facility operations.

B. Water Resources will notify Fish and Game well in advance of any scheduled outages and at the time of unscheduled outages, if such outages might affect the effectiveness of the screens at the Skinner Facility. Water Resources is in the process of installing an auxiliary power source to prevent outages from occurring. If, however, the screens are inoperative, Water Resources will stop diversions through the Pumping Plant unless there is an emergency situation and water is not available from any other source for direct deliveries or unless Fish and Game has determined that the adverse impact on fish is not sufficient to justify cessation of pumping. In making its determination, Fish and Game will consider the kind and numbers of fish present and the State Water Project's need for water as determined by Water Resources.

C. The Skinner Facility will be operated in conformance with mutually acceptable criteria to maximize protection of the Delta fishery.

V. The parties agree that State Water Project Pumping Plant diversions cause direct losses of some species other than striped bass, steelhead and chinook salmon, e.g., American shad and sturgeon.

A. At this time not enough information is available to determine either what the impact of such diversions is on such species or what measures are appropriate to offset such losses. Water Resources and Fish and Game are involved in a variety of studies to determine what the impacts are and what can be done to reduce or eliminate identified adverse impacts. Fish and Game will prepare a report on these subjects by March 1987.

B. Measures to offset losses for fish species not covered in this agreement shall be included when information is obtained to develop effective measures. Measures provided under this agreement will benefit some of these species.

VI. By December 31, 1989, and by December 31 of each year thereafter, Water Resources and Fish and Game shall, with input from the advisory committee set forth in Section I.F, review the success of this agreement in offsetting the direct effects of diversions by the Pumping Plant on fisheries dependent on the Delta. If the agreement is not successful in this regard, it shall be renegotiated to fulfill the State Water Project's responsibilities relating to the direct effects of diversions by the Pumping Plant. The parties will provide an annual report describing the results of the annual review.

VII. Upon execution of this agreement, the parties will begin discussions on developing ways to offset the adverse fishery impacts of the State Water Project which are not covered in this agreement, including facilities needed to offset fishery impacts and provide more efficient conveyance of water. Until agreement is reached between the parties on offsetting such impacts, Water Resources will not increase diversions beyond those set forth in the U.S. Corps of Engineer's Public Notice 5820A, amended, dated October 13, 1981 and Fish and Game shall not unreasonably withhold its approval of such agreement.

VIII. The parties will make every effort to involve the Federal Government in the development of programs which would offset similar impacts of the Federal Central Valley Project.

IX. This agreement is intended to offset direct losses of fish resources caused by State Water Project Pumping Plant diversions. Therefore, Water Resources and Fish and Game will not object to the participation of groups concerned with protecting such fish resources in legal proceedings to enforce this agreement.

Dated: 12-30-86

Dated: December 30, 1986

David N. Kennedy, ~~Director~~
Department of Water Resources

Jack C. Parnell, Director
Department of Fish and Game

Approved as to legal form
and sufficiency:

Chief Counsel, Department
of Water Resources

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